Y/UB-8

#948

ENVIRONMENTAL MONITORING REPORT

UNITED STATES
DEPARTMENT OF ENERGY
OAK RIDGE FACILITIES

Calendar Year 1977

UNION CARBIDE

NUCLEAR DIVISION
OAK RIDGE, TENNESSEE

prepared for the U.S. DEPARTMENT OF ENERGY *under*
U.S. GOVERNMENT *Contract W-7405 eng 26*

APPROVAL FOR RELEASE

Document: # Y/UB-8 ; Date 6/21/78 ;

Title/Subject ENVIRONMENTAL MONITORING REPORT

US DOE OAK RIDGE FACILITIES, CY 1977

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A S Quist — 12/28/92

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Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Paper Copy $5.25; Microfiche $3.00 (domestic); $4.50 (foreign)

Y/UB-8
Date of Issue: June 21, 1978

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UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE FACILITIES

Calendar Year 1977

UNION CARBIDE CORPORATION – NUCLEAR DIVISION
Oak Ridge Gaseous Diffusion Plant
Oak Ridge National Laboratory
Oak Ridge Y-12 Plant

Office of Health, Safety, and Environmental Protection
Post Office Box Y
Oak Ridge, Tennessee 37830

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INTRODUCTION

Oak Ridge is located in East Tennessee in a broad valley which lies between the Cumberland Mountains on the northwest and the Great Smoky Mountains on the southeast. The Department of Energy (DOE) Reservation is located in the Valley and Ridge physiographic province which is characterized by parallel ridges of sandstone, shale, and cherty dolomite, separated by valleys of less weather-resistant limestone and shale. The ridges are oriented southwest-northeast. Topography of the area is due to differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Elevations range from 740 feet to 1360 feet above mean sea level with a maximum relief of 620 feet. The area includes gently sloping valleys and rolling to steep slopes and ridges. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar Reservoirs on the Clinch River form the southern and western boundaries of the Reservation while the City of Oak Ridge (approximately 28,000 population) is on the northern boundary.

The local climate is noticeably influenced by topography. Prevailing winds are usually either up-valley, from west to southwest, or down-valley, from east to northeast. During periods of light winds, daytime winds are usually southwesterly and nighttime winds usually northeasterly. Wind velocities are somewhat decreased by the mountains and ridges, and tornadoes rarely occur. In winter, the Cumberland Mountains have a moderating influence on the local climate by retarding the flow of cold air from the north and west. Temperatures of 100°F or higher and 0°F or below are unusual. Low-level temperature inversions occur during approximately 56 percent of the hourly observations. Winter and early spring are the seasons of heaviest precipitation with the monthly maximum normally occurring during January to March. The mean annual precipitation is approximately 54 inches.

The topography of the Oak Ridge Area is such that all drainage from the DOE Reservation flows into the Clinch River which has its headwaters in southwestern Virginia and flows southwest to its mouth near Kingston, Tennessee. The Clinch River flow is regulated by several dams which provide reservoirs for flood control, electric power generation, and recreation. The principal tributaries through which liquid effluents from the plant areas reach the Clinch River are White Oak Creek, East Fork Poplar Creek, and Poplar Creek.

With the exception of the City of Oak Ridge, the land within 5 miles of the DOE Reservation is predominantly rural being utilized largely for residences, small farms, and pasturage for cattle. The approximate location and population of the towns nearest the DOE Reservation are: Oliver Springs (pop. 3400) 7 miles to the northwest; Clinton (pop. 4800) 10 miles to the northeast; Lenior City (pop. 5300) 7 miles to the southeast; Kingston (pop. 4100) 7 miles to the southwest; and Harriman (pop. 8700) 8 miles to the west. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 25 miles to the east and has a population of approximately 175,000. A directional 80-km (50-mile) population distribution, which is used for population dose calculations later in this report, is shown in Table 1.

The DOE Reservation contains three major operating facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Gaseous Diffusion Plant (ORGDP), and the Y-12 Plant; all of which are operated by Union Carbide Corporation, Nuclear Division. In addition, two smaller DOE facilities are in the area: the Comparative Animal Research Laboratory, and the Oak Ridge Associated Universities.

The Oak Ridge National Laboratory is a large multipurpose research laboratory whose basic mission is the discovery of new knowledge, both basic and applied, in all areas related to energy. To accomplish this mission, the Laboratory conducts research in all fields of modern science and technology. The Laboratory's facilities consist of nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities.

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is a complex of production, research, development, and support facilities located west of the city of Oak Ridge. While the primary function of ORGDP is the enrichment of uranium hexafluoride (UF_6) in the uranium-235 isotope, extensive efforts are also expended on research and development activities associated with both the gaseous diffusion and gas centrifuge processes. In addition, the barrier material used by all three Department of Energy-owned gaseous diffusion plants is manufactured at ORGDP. Numerous other activities (maintenance, nitrogen production, steam production, uranium recovery, fluorine production, water treatment, laboratory analysis, administration, etc.) lend support to these primary functions and are thus essential to the operation of this plant.

The Oak Ridge Y-12 Plant which is located immediately adjacent to the City of Oak Ridge has four major responsibilities: (1) production of nuclear weapon components, (2) fabrication support for weapon design agencies, (3) support for the Oak Ridge National Laboratory, and (4) support and assistance to other government agencies. Activities associated with these functions include the production of lithium compounds, the recovery of enriched uranium from unirradiated scrap material, and the fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Operations associated with the DOE research and production facilities in Oak Ridge give rise to several types of waste materials.

Radioactive wastes are generated from nuclear research activities, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, uranium enrichment, and uranium processing operations. Nonradioactive wastes are generated by normal industrial-type support operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plant operations, and steam plant operations.

Nonradioactive solid wastes are buried in a centralized sanitary landfill or designated burial areas. Radioactive solid wastes are buried in designated burial areas or placed in retrievable storage either above or below ground depending upon the type and quantity of radioactive material present and the economic value involved.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques prior to release to the atmosphere. The major gaseous waste streams are released through stacks to provide atmospheric dilution for materials which may remain in the stream following treatment.

Liquid radioactive wastes are not released but are concentrated and contained in tanks for ultimate disposal. Process water which may contain small quantities of radioactive or chemical pollutants is discharged, after treatment, to White Oak Creek, Poplar Creek, East Fork Poplar Creek, and Bear Creek, which are small tributaries to the Clinch River.

SUMMARY

The Environmental Monitoring Program for the Oak Ridge area includes sampling and analysis of air, water from surface streams, creek sediments, biota, and soil for both radioactive and nonradioactive materials. This report presents a summary of the results of the program for calendar year 1977.

Surveillance of radioactivity in the Oak Ridge environs indicates that atmospheric concentrations of radioactivity were not significantly different from other areas in East Tennessee. Concentrations of radioactivity in the Clinch River and in fish collected from the river were less than 6 percent of the permissible concentration and intake guides for individuals in the offsite environment. While some radioactivity was released to the environment from plant operations, the concentrations in all of the media sampled were well below established standards.

The total body dose to a "hypothetical maximum exposed individual" at the site boundary was calculated to be 7.2 mrem/yr which is 1.4 percent of the DOE Manual Chapter 0524 standard. The maximum 50-year dose commitment to the critical organ of an individual from the aquatic food chain was calculated to be 110 millirem to the bone which is 7.3 percent of the allowable annual standard. The maximum dose commitment to individuals living nearest the site boundary from airborne releases, assuming continuous residence, was 0.13 millirem to the total body and 4.6 millirem to the lung. These doses are 0.03 percent and 0.3 percent, respectively, of the annual standards. The average total body dose to an Oak Ridge resident was estimated to be 0.04 millirem as compared to approximately 100 mrem/yr from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.3 millirem. The cumulative total body dose to the population within a 50-mile radius of the Oak Ridge facilities resulting from 1977 effluents was calculated to be 4.7 man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation.

Surveillance of nonradioactive materials in the Oak Ridge environs shows that established limits were not exceeded for those materials possibly present in the air as a result of plant operations with the exception of fluorides which exceeded the limits on several occasions. Several abatement projects to reduce fluoride emissions became fully operational in 1977. The ORGDP steam plant was out of compliance with State emission limits for particulates

and visible emissions during the winter months. The steam plant boilers now utilize coal as the primary fuel.

One electrostatic precipitator has been installed and another is under construction for particulate removal. It is planned to meet SO_2 emission standards through the purchase of suitable quality coal.

The chemical water quality data in surface streams obtained from the water sampling program indicated that average concentrations resulting from plant effluents were in compliance with State stream guidelines with the exception of fluorides which were slightly over the limit.

National Pollutant Discharge Elimination System (NPDES) permit compliance information has been included in this report.

MONITORING DATA
COLLECTION, ANALYSIS, AND EVALUATION

Environmental monitoring data for calendar year 1977 are summarized in Tables 2 through 33. In general, the data tables show the number of samples collected at each location, the maximum concentration, the minimum concentration, the average concentration, the relevant standard, and percent of standard for the average of each parameter. Averages are usually accompanied by plus-or-minus (±) values which represent the 95 percent confidence limits. The 95 percent confidence limits which are calculated from the standard deviation of the average, assuming a normal frequency distribution, are predictions of the variability in the range of concentrations based on a limited number of measurements. They do not represent the conventional error in the average of repeated measurements on identical samples. Data which are below the minimum detectable limit are expressed as less than (<) the minimum detectable value. In computing average values, sample results below the detection limit are assigned the detection limit value with the resulting average value being expressed as less than (<) the computed value.

Average environmental concentrations are compared with applicable standards, where such standards have been established, as a means of evaluating the impact of effluent releases. In some cases, for lack of an official standard, stream concentrations of nonradioactive pollutants have been compared with Tennessee State Health Department stream guidelines.

Liquid effluent monitoring data have been compared to the limits specified in the National Pollutant Discharge Elimination System (NPDES) permits issued to the Oak Ridge Facilities by the Environmental Protection Agency (EPA).

Air Monitoring

Radioactive — Atmospheric concentrations of radioactive materials occurring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of nine stations (HP-31 through HP-39) which encircle the perimeter of the Oak Ridge area and provides data for evaluating releases from Oak Ridge facilities to the immediate environment, Figure 1. A second system consists of eight stations (HP-51 through HP-58) encircling the Oak Ridge area at distances of from 12 to 75 miles, Figure 2. This system provides background data to aid in evaluating local conditions. Sampling for radioactive particulates is carried out by passing air continuously through filter papers. Filter papers are evaluated weekly by gross beta and gross alpha counting techniques and composited quarterly by system for specific radionuclide analysis during normal operations. More frequent detailed analyses are performed if concentrations in the environment are significantly above normal. Airborne radioactive iodine is monitored in the immediate environment (HP-31 through HP-39) by passing air continuously through cartridges containing activated charcoal. Charcoal cartridges are evaluated for radioactive iodine by gamma spectrometry.

Data on the concentrations of radioactive materials in air and the quantities of radioactive materials released to the atmosphere in the Oak Ridge and surrounding areas are given in Tables 2 through 6.

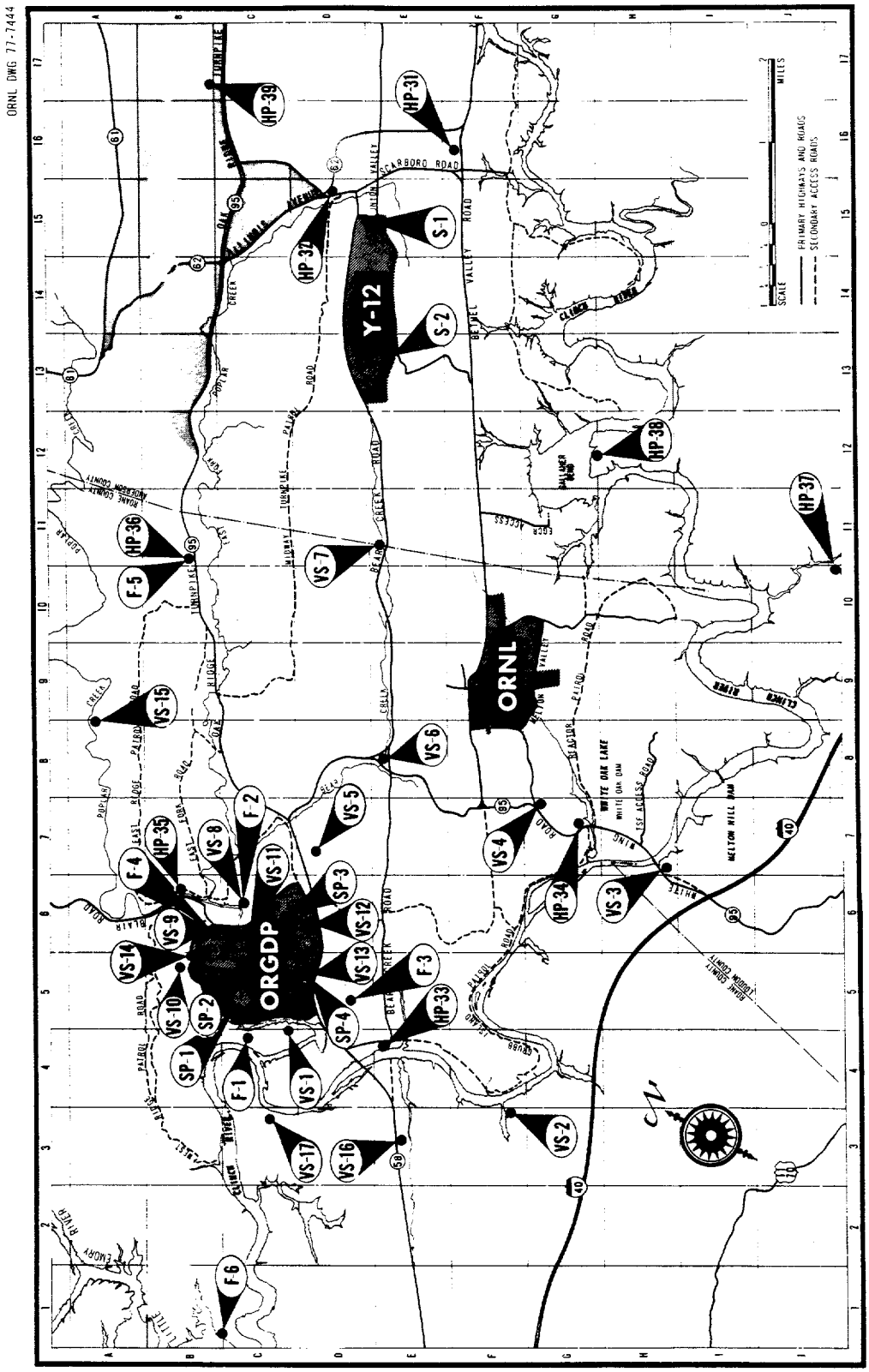

Figure 1
AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

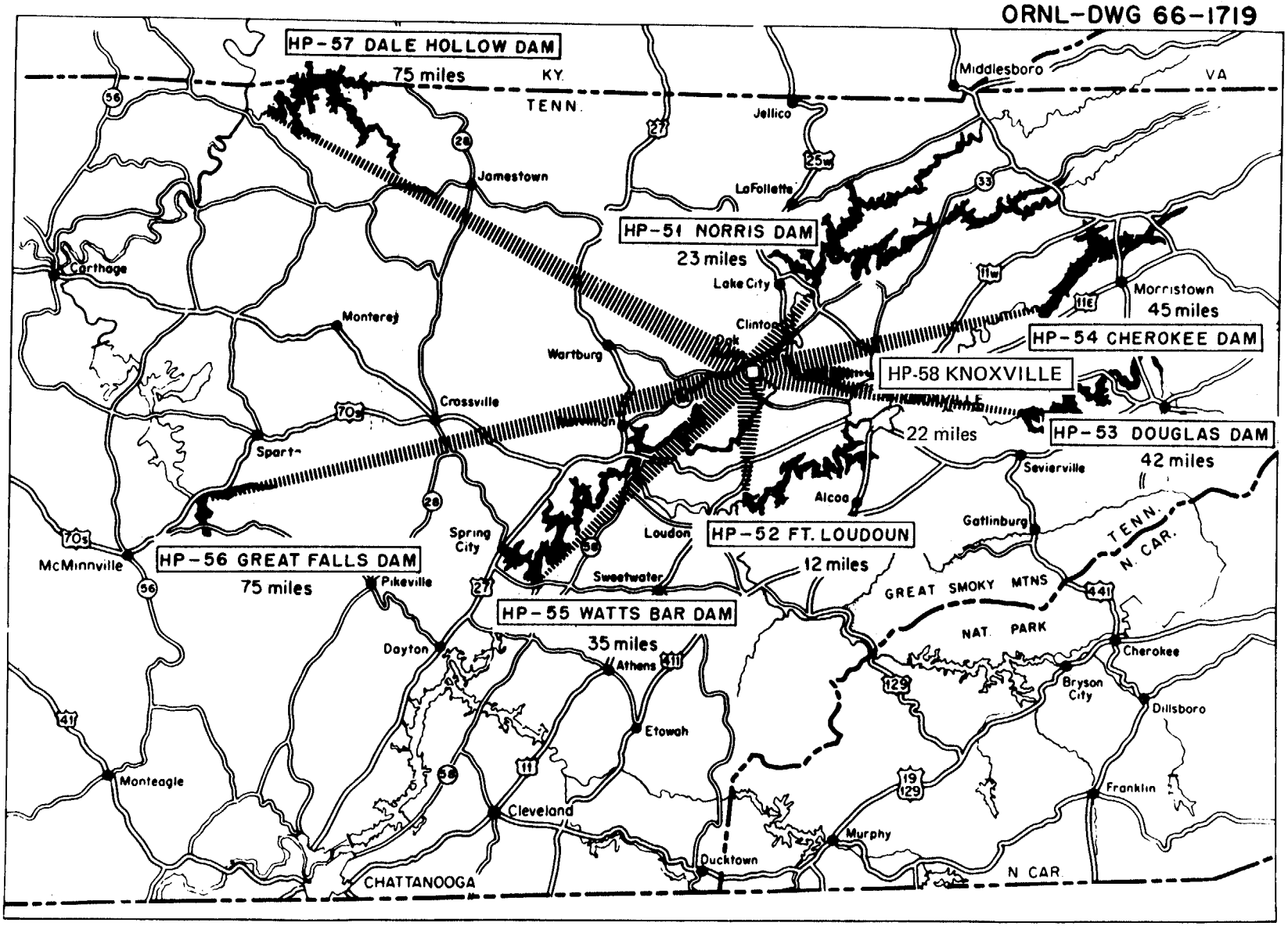

Figure 2

STATION SITES FOR REMOTE AIR MONITORING SYSTEM

The average gross beta concentrations of radioactivity from particulates in air measured by both the perimeter and remote monitoring systems were 0.04 and 0.05 percent, respectively, of the applicable concentration guide (CG) as specified in the DOE Manual, Appendix 0524[1] for individuals in uncontrolled areas (Table 2).

The average gross alpha concentrations in the perimeter and remote monitoring systems were 0.03 and 0.02 percent, respectively, of the CG for a mixture of uranium isotopes (Table 3).

The results of specific radionuclide analyses of composited filters are given in Table 4. The higher levels noted for uranium in the perimeter system are attributed to airborne releases from uranium enrichment and processing operations at ORGDP and the Y-12 Plant. The environmental concentrations tabulated are all at least a thousand times less than the applicable DOE concentration guides for the radionuclides detected.

The concentration of ^{131}I as measured by the perimeter air monitoring system was <0.01 percent of the inhalation concentration guide for individuals in uncontrolled areas (Table 5).

While some radioactivity was released to the atmosphere (Table 6), measurements in the Oak Ridge area show that environmental levels were well below established standards.

Nonradioactive — Environmental air samples are taken for the determination of fluorides, suspended particulates, and sulfur dioxide.

Sampling locations for fluorides are indicated by F-1 through F-6, Figure 1. In the past, concentrations were determined by collecting 24-hour samples in caustic solution in a Boyce-Thompson type sampler on an 8-day frequency and analyzing the resulting solution by specific ion electrode. During August, 1977 the sampling procedure was altered to obtain 7-day samples collected on potassium carbonate treated paper and to analyze weekly by specific ion electrode.

Suspended particulates are measured at locations SP-1 through SP-4, Figure 1. The method for the determination of suspended particulates is the high volume method recommended by EPA. Particulates are collected by drawing air through weighed filter paper. The filter paper is allowed to equilibrate in a humidity controlled atmosphere and the filter is reweighed. From the weight of particulates, the sampling time, and the air flow rate, the particulate concentration in micrograms per cubic meter is calculated. The sampling period is 24 hours.

Two continuous monitoring stations (S-1 and S-2) were installed in the Y-12 Plant area for the measurement of ambient concentrations of sulfur dioxide. Each station consists of a flame photometric continuous analyzer and recorder with associated equipment located in a temperature controlled shelter. Sulfur dioxide concentrations are interpreted on an hourly basis and averaged for 24 hour, monthly, and annual periods.

Air monitoring data for fluorides, suspended particulates, and sulfur dioxide are presented in Tables 7 through 9. These data indicate that average environmental concentrations of particulates and sulfur dioxide were in compliance with applicable standards[2] during calendar year 1977. Fluoride concentrations exceeded the standards on several occasions. However, the concentration of fluorides at Station F-6, which is five miles from Oak Ridge operations, indicates that the ambient fluoride background levels may be generally high in the area and makes interpretation of the incremental addition from Oak Ridge operations somewhat difficult.

Steam plant operations were in compliance with State emission limits except for the steam plant at ORGDP. The particulate emissions for the ORGDP steam plant do not comply with Tennessee standards when coal is burned. The particulate standard states that no more than 0.1 pound of particulates may be discharged for each one million Btu's of heat input. The latest measurement of the ORGDP steam plant effluent indicates that 0.8 to 1.0 pound of particulates is released for each one million Btu's input when coal is burned. Electrostatic precipitators for removal of particulate matter are expected to be installed and operable by mid 1978 at which time the steam plant should be in compliance with the particulate standard.

External Gamma Radiation Monitoring

External gamma radiation background measurements are made routinely at eight of the perimeter air monitoring stations, at one station located near Melton Hill Dam, and at the remote monitoring stations using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations and Melton Hill Dam are collected and analyzed monthly. Those at the remote stations are collected and analyzed semiannually.

Data on the average external gamma radiation background are given in Table 10. The slight difference between the average levels in the perimeter and remote environs is considered to be within the variation in background levels normally experienced in East Tennessee which is dependent upon elevation, topography, and geological character of the surrounding soil.[3]

External gamma radiation measurements were performed along the stream course of East Fork Poplar Creek to evaluate radioactivity which might be contained in the sediments as a result of effluent releases. Additionally, measurements were made along the bank of the Clinch River from the mouth of White Oak Creek several hundred yards downstream to evaluate gamma radiation levels resulting from effluent releases and "sky shine" from an experimental ^{137}Cs plot located near the river bank. Measurements were made using scintillation detectors and/or thermoluminescent dosimeters suspended one meter above the ground surface. The average background level determined at the perimeter stations was subtracted from the measured gamma radiation levels to determine the incremental increases resulting from plant operations.

Gamma levels along East Fork Poplar Creek ranged from 0 to 12 μR/hr above background. The external gamma radiation levels along the bank of the Clinch River ranged from 3 to 30

μR/hr above background. Potential doses to individuals in the environment from these elevated gamma radiation levels were evaluated and are included, where significant, in the dose assessment section of the report.

Water Monitoring

Radioactive — Water samples are collected in the Clinch River for radioactivity analyses at Melton Hill Dam (Station C-2) 2.3 miles above White Oak Creek outfall, at the ORGDP sanitary water intake (Station C-3) 6.3 miles downstream from the entry of White Oak Creek, at the ORGDP recirculating water intake (Station C-4) downstream from the Poplar Creek outfall, near Brashear Island (Station C-6), and at Center's Ferry (Station C-5) near Kingston, Tennessee, Figure 3. Samples are collected continuously at all locations except for Station C-5 and Station C-6 which are collected on a daily and monthly grab-sample basis, respectively. Samples are composited for monthly or quarterly analysis depending upon location.

Water samples also are collected for radioactivity analyses at White Oak Dam (Station W-1), at the outlet of New Hope Pond on East Fork Poplar Creek (Station E-1), in Bear Creek (Station B-1), and in Poplar Creek (Stations P-1 and P-2), Figure 3. The samples collected at Stations W-1, E-1, and B-1 are continuous proportional samples. Twenty-four hour composite samples are collected at Stations P-1 and P-2 on a weekly basis. All samples are composited for monthly analysis.

The concentrations of fission product radionuclides present in detectably significant amounts are determined by specific radionuclide analysis and gamma spectrometry. Uranium analysis is by the fluorometric method. Transuranic alpha emitters are determined by ion exchange and alpha range analysis. The concentration of each radionuclide is compared with its respective concentration guide (CG) value as specified in the DOE Manual, Appendix 0524, and percent of concentration guide for a known mixture of radionuclides is calculated in accordance with the method given in Appendix 0524.

Data on the concentrations of fission product radionuclides, uranium in surface streams, and the quantities of radioactivity released to surface streams are given in Tables 11 through 13. The average concentrations of specific radionuclides in offsite surface streams at all points of measurement were less than 1 percent of the applicable concentration guides for uncontrolled areas.

The average concentration of transuranic alpha emitters in the Clinch River at Clinch River Mile (CRM) 20.8 resulting from effluent releases was 7×10^{-12} μCi/ml, which is less than 0.01 percent of the concentration guide for water containing a known mixture of radionuclides.*

Rainwater — The gross beta activity in rainwater was analyzed; the results are shown in Table 14. The fluctuations among the stations for both the perimeter and remote networks are due to statistical random variation. It is noted that the average radioactivity is greater for the remote stations than the perimeter stations.

*CG determined by method given in DOE Manual, Appendix 0524 for determining the concentration guide for a known mixture of radionuclides.

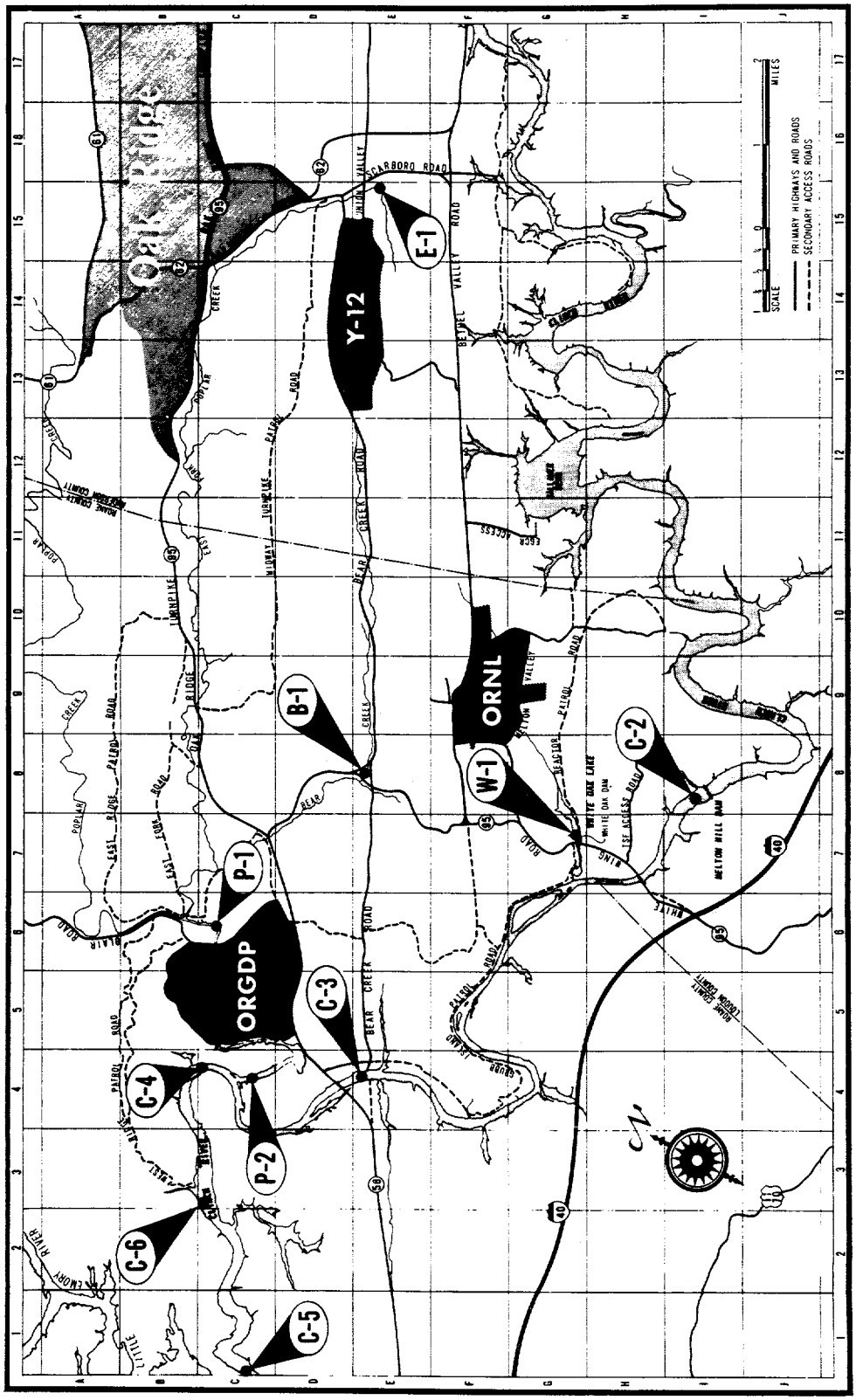

Figure 3
STREAM MONITORING LOCATIONS

Nonradioactive – Water samples are collected for the analysis of nonradioactive substances at the same locations discussed previously under radioactive water sampling. All samples are composited for monthly analysis. Samples are analysed for a variety of water quality parameters related to process release potential and background information needs by analytical procedures recommended by the Environmental Protection Agency.[4]

Data on chemical concentrations in surface streams are given in Tables 15 through 23. The average concentrations of all substances analyzed were in compliance with Tennessee stream guidelines[5] except for fluorides at Station E-1 which was 110 percent of the guidelines (the primary source of fluorides is fluoridated water from the Oak Ridge water treatment plant).

Dissolved oxygen (DO) and pH measurements are made continuously at White Oak Dam (Station W-1). Measurements of dissolved oxygen and pH at White Oak Dam indicated DO values ranging from 3 to $>$ 15 mg/l and pH values from 6.4 to 9.5. The dissolved oxygen was out of compliance with the State standard[6] on 34 occasions and the pH was out of compliance with the State standard on 61 separate occasions. Noncompliance of DO and pH at White Oak Dam was attributed to natural causes.

National Pollutant Discharge Elimination System (NPDES) permits were issued by the Environmental Protection Agency (EPA) for each of the Oak Ridge facilities operated by Union Carbide Corporation - Nuclear Division in 1975. The permits established a number of discharge locations at each installation and listed specific concentration limits and/or monitoring requirements for a number of parameters at each discharge location. Table 24 contains the discharge locations at each installation, the parameters at each location for which limits have been established, the permit limits for each parameter, and the percentage compliance experienced.

Biological Monitoring

Milk – Raw milk is monitored for ^{131}I and ^{90}Sr by the collection and analysis of samples from 13 sampling stations located within a radius of 50 miles of Oak Ridge. Samples are normally collected weekly at each of eight stations located near the Oak Ridge area. Five stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. Milk sampling locations for all stations are shown in Figures 4 and 5. Samples are analyzed by ion exchange and gamma spectrometry; results are compared to intake guides specified by the Federal Radiation Council (FRC).[7]

The average concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 25 and 26, respectively. If one assumes the average intake of milk per individual to be one liter per day, the average concentration of ^{131}I in the milk in both the immediate environs of the Oak Ridge area and in the environs remote from Oak Ridge were within FRC Range I.

The concentration of ^{131}I in milk is very sensitive to atmospheric weapons testing. This is demonstrated in Figure 6 which shows the weekly average iodine-131 concentrations of the eight local milk stations following the Chinese atomic-bomb explosion on September 17. The rapid rise and fall of the levels can be noted.

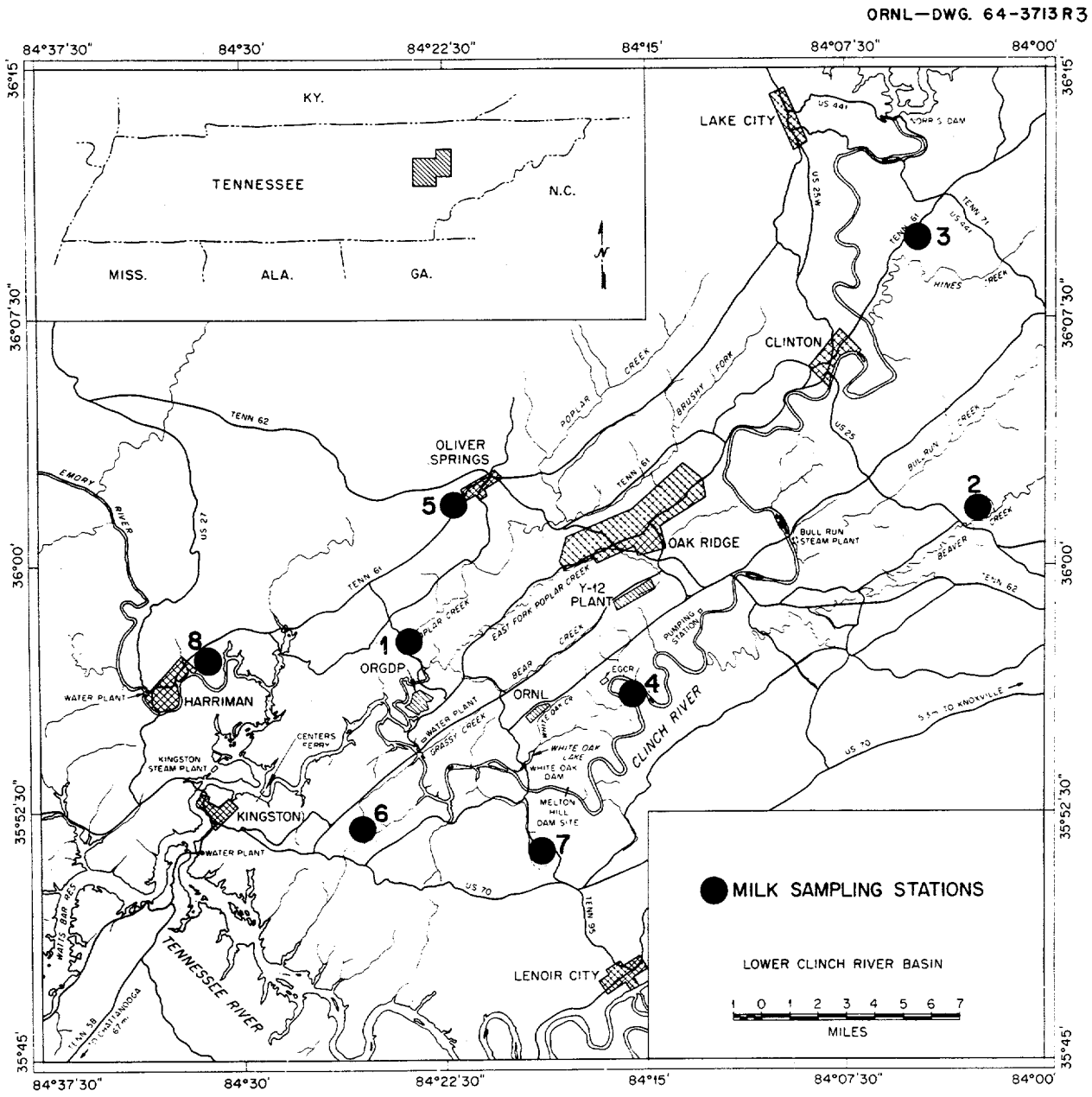

Figure 4
IMMEDIATE ENVIRONS MILK SAMPLING LOCATIONS

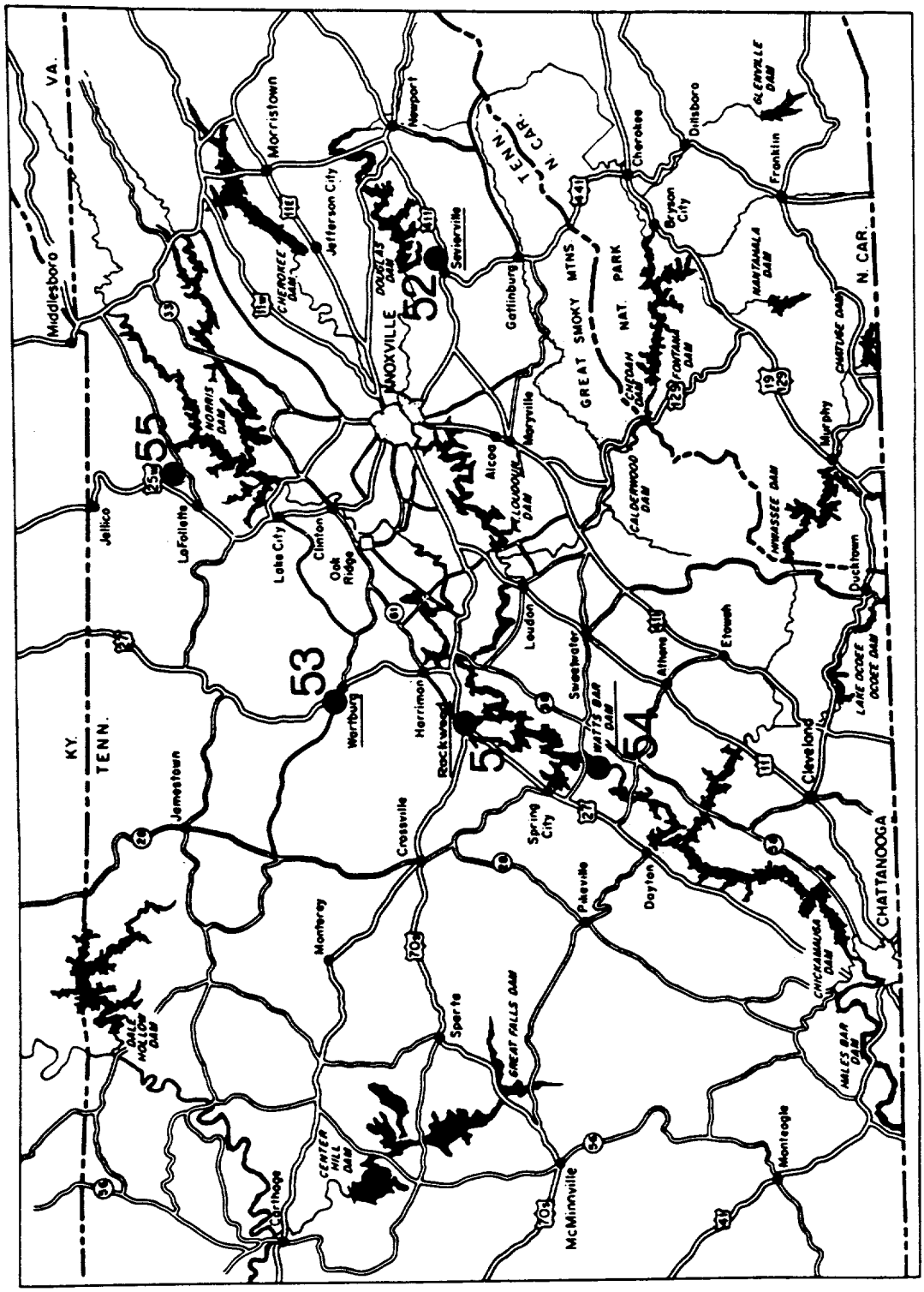

Figure 5

REMOTE ENVIRONS MILK SAMPLING LOCATIONS

The average concentrations of ^{90}Sr in milk from both the immediate and remote environs were within the FRC Range I. The concentration of ^{90}Sr in milk is different at different locations; part of the variation has been found to result from differences in farming methods used at different farms. Pastureland that is not fertilized and is overgrazed (a not too uncommon practice in this area) apparently results in a higher than normal concentration of ^{90}Sr in milk from cows pastured on this land.

Fish Sampling – Several species of fish which are commonly caught are taken from the Clinch River during the spring and summer of each year. The scales, head, and entrails are removed from the fish before ashing. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Data on the concentrations of radionuclides in Clinch River fish are given in Table 27. Consumption of 37 pounds of bluegill per year[8] taken from the river near White Oak Creek outfall results in approximately 6 percent of the maximum permissible intake, which represents the highest dose potential to the public from fish consumption. The maximum permissible intake is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of the radionuclides in question.

Deer – Occasionally, deer are killed by automobiles on the DOE Reservation. Eight road-killed deer samples were analyzed during 1977 for gamma emitters, and the data is presented in Table 28. Deer samples 1 and 2 are considered background samples, since they were not on the Oak Ridge Reservation. The radioactivity present in all the muscle samples could be attributed to world-wide fallout, except for deer samples 4 and 5 which could be attributed to radioactivity on the site. Deer sample 4 was found near White Oak Creek, and the dose from consumption of 1 kg of this deer is 0.1 mrem to the total body and 0.25 mrem to the liver (critical organ). It should be noted that no hunting is allowed on the Oak Ridge Reservation.

Vegetation – Samples of pine needles and grass are collected semiannually from 17 areas (Stations VS-1 through VS-17, Figure 1) and analyzed for uranium and fluoride content. Fluorometric analysis is used for the determination of uranium and colorimetric analysis is used for the determination of fluorides.

Data on the uranium and fluoride content in vegetation are presented in Table 29. The fluoride concentration in grass at all sampling points was below the 30 ppm level considered to produce no adverse effects when ingested by cattle.[9] Uranium concentrations were below levels of environmental concern.

Additionally, samples of grass were collected from the perimeter and remote air-sampling stations (see Figures 1 and 2). At each station, all the grass from five 1/5-meter-squared plots was collected. One plot was taken beside the station, and the other four were taken at 15 m from the station at 90° directions from each other. The grass from each station

was then composited and analyzed by gamma spectrometry and radiochemical techniques for a variety of radionuclides. Data on the radionuclide concentrations in grass are presented in Table 30.

Soil and Sediment Monitoring

Soil – Soil samples are also collected annually from near the perimeter and remote stations. The same five 1/5-meter-squared plots used for grass analysis were also used for soil determinations. Two cores, 8 cm in diameter and 5 cm in depth, were taken from each plot; a composite of 10 cores was used for each station. These samples were also analyzed by gamma spectrometry and radio-chemical techniques.

A distribution plot of the uranium in soils at the various perimeter and remote stations is shown in Figure 7. For a distribution plot, the concentration at each station is plotted versus its ranking in the distribution. Using this type of plot, it can readily be seen whether the data belong to the same or different statistical populations. It is shown in Figure 7 that the ^{235}U from the perimeter stations have a different and higher distribution than the remote stations. Further, Stations 35, 39, and 32, which have the highest values, form a still higher distribution than the rest of the perimeter stations; these stations are directly northeast (dominant wind direction) of the ORGDP and Y-12 Plants (see Figure 1). Thus, they experience the greatest impact from the atmospheric effluent releases.

In assessing the ^{238}U in the soil at the various stations, the perimeter and remote soils appear to come from the same statistical distribution; the exceptions are Stations 32 and 39. Again, they are the two stations directly northeast of the Y-12 Plant. Station 37 has the lowest value for both ^{235}U and ^{238}U in soils. This is due to the fact that it is not greatly influenced by the plant's atmospheric releases because of its location (see Figure 1).

A distribution plot of ^{239}Pu in the perimeter and remote soils is shown in Figure 8. The concentration of ^{239}Pu at the remote stations is relatively constant; the values for the perimeter stations, however, demonstrate a wider range.

Data on specific radionuclide concentrations in soil are given in Table 31. The plutonium concentrations found were comparable to the value of 0.05 pCi/g considered to be a representative concentration of plutonium in U.S. surface soil.[10]

Sediment – A sediment sampling program, containing eight sampling locations, was initiated in 1975 to determine the concentrations of various metallic ions in the sediment of Poplar Creek. This program was expanded in 1976 to a total of 17 sampling locations and in 1977 to 20 locations, including two sampling locations on the Clinch River, 17 sampling locations on Poplar Creek, and one sampling location on East Fork Poplar Creek. The 20 sediment sampling locations are shown in Figure 9. Samples are collected twice during the year and analyzed by atomic absorption.

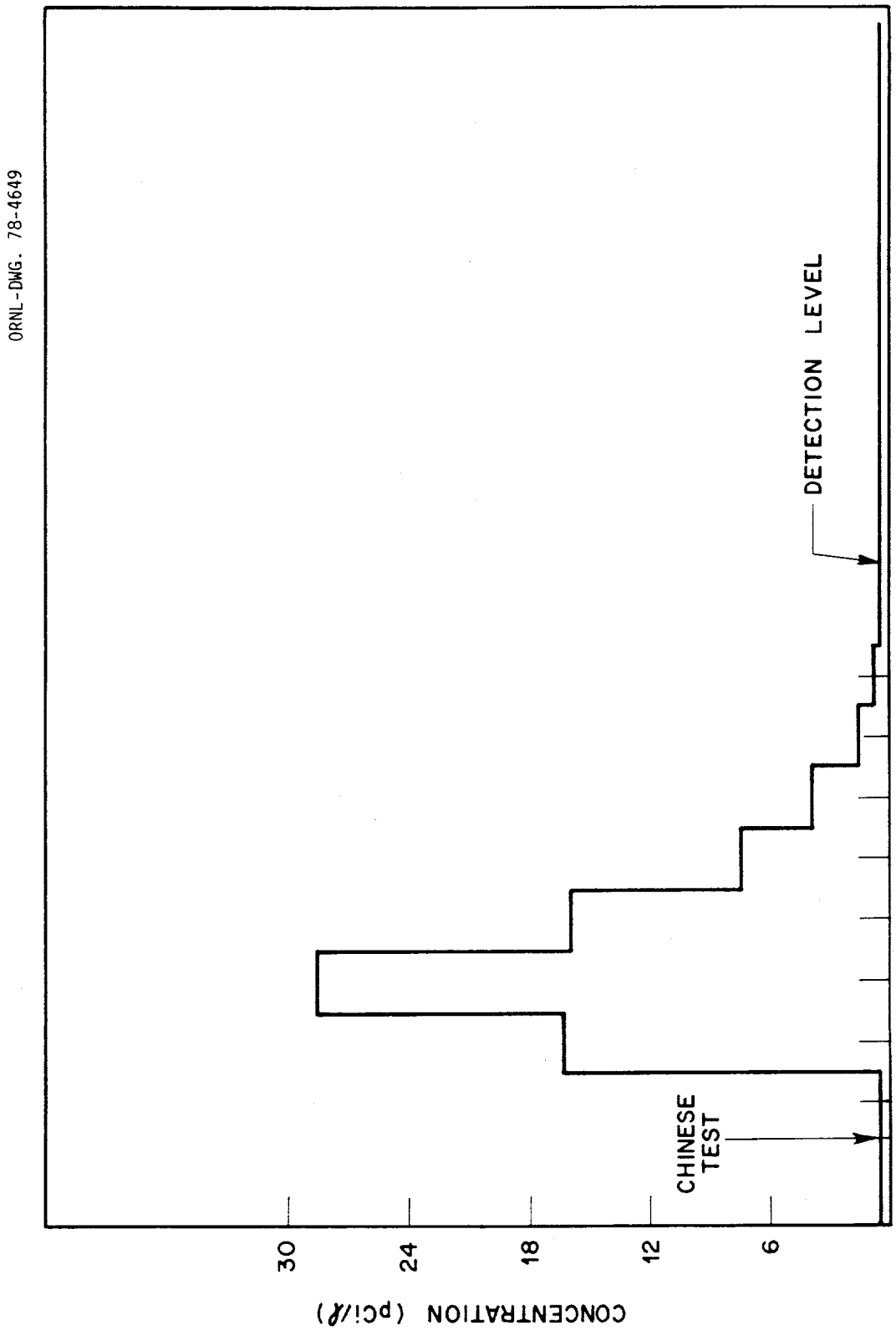

Figure 6
IODINE-131 CONCENTRATIONS IN MILK

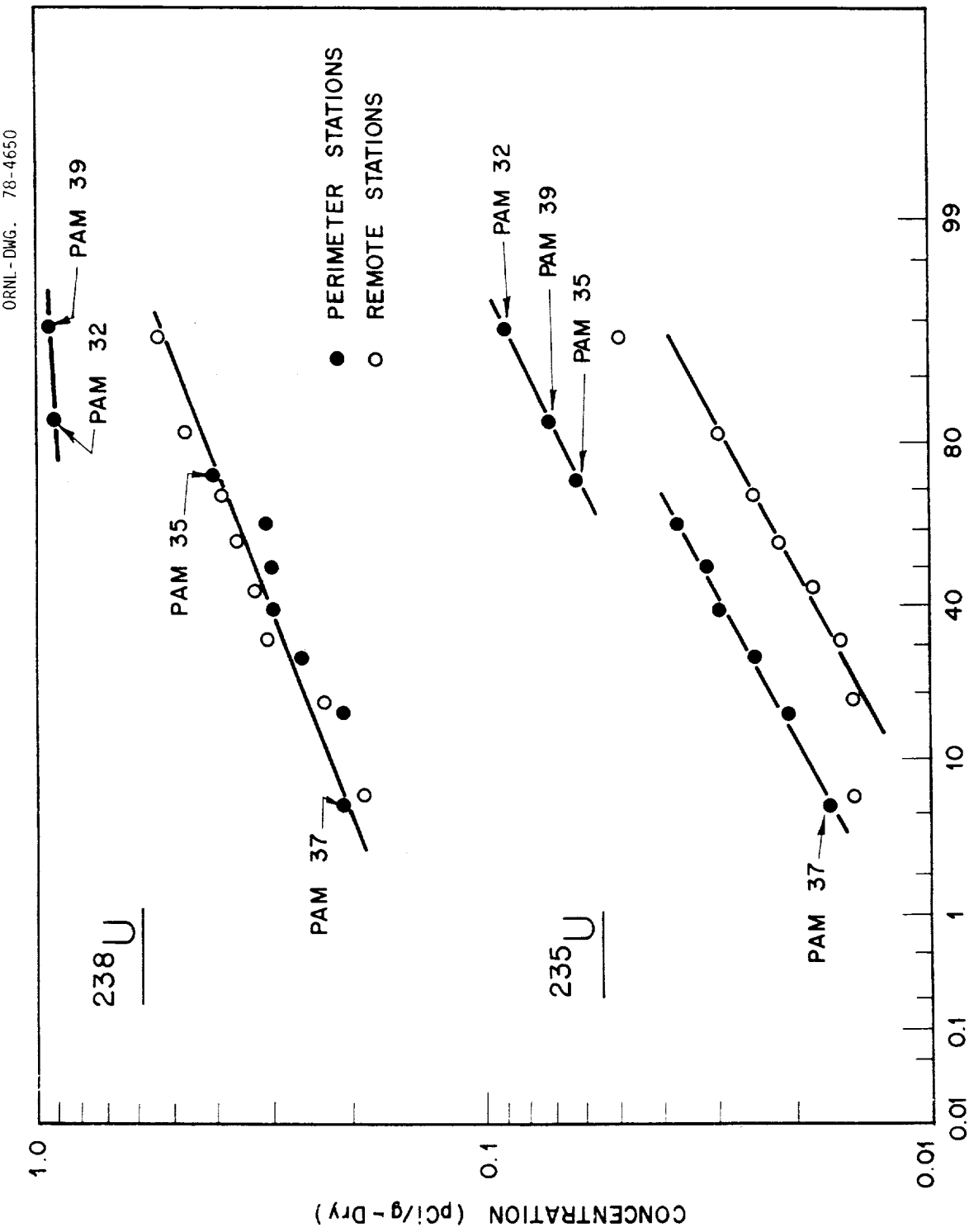

Figure 7
DISTRIBUTION PLOT OF URANIUM IN SOIL

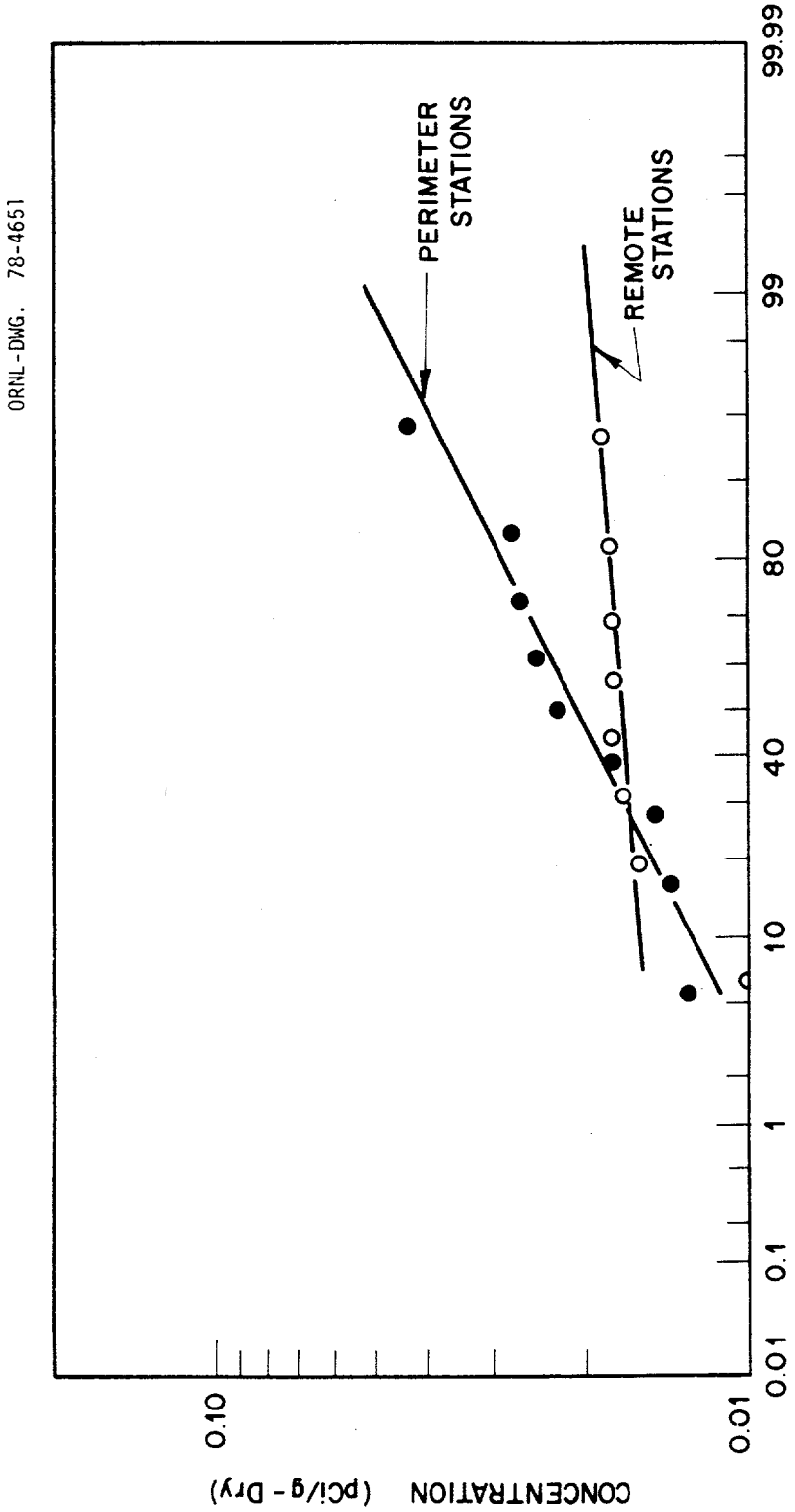

Figure 8
DISTRIBUTION PLOT OF PLUTONIUM-239 IN SOIL

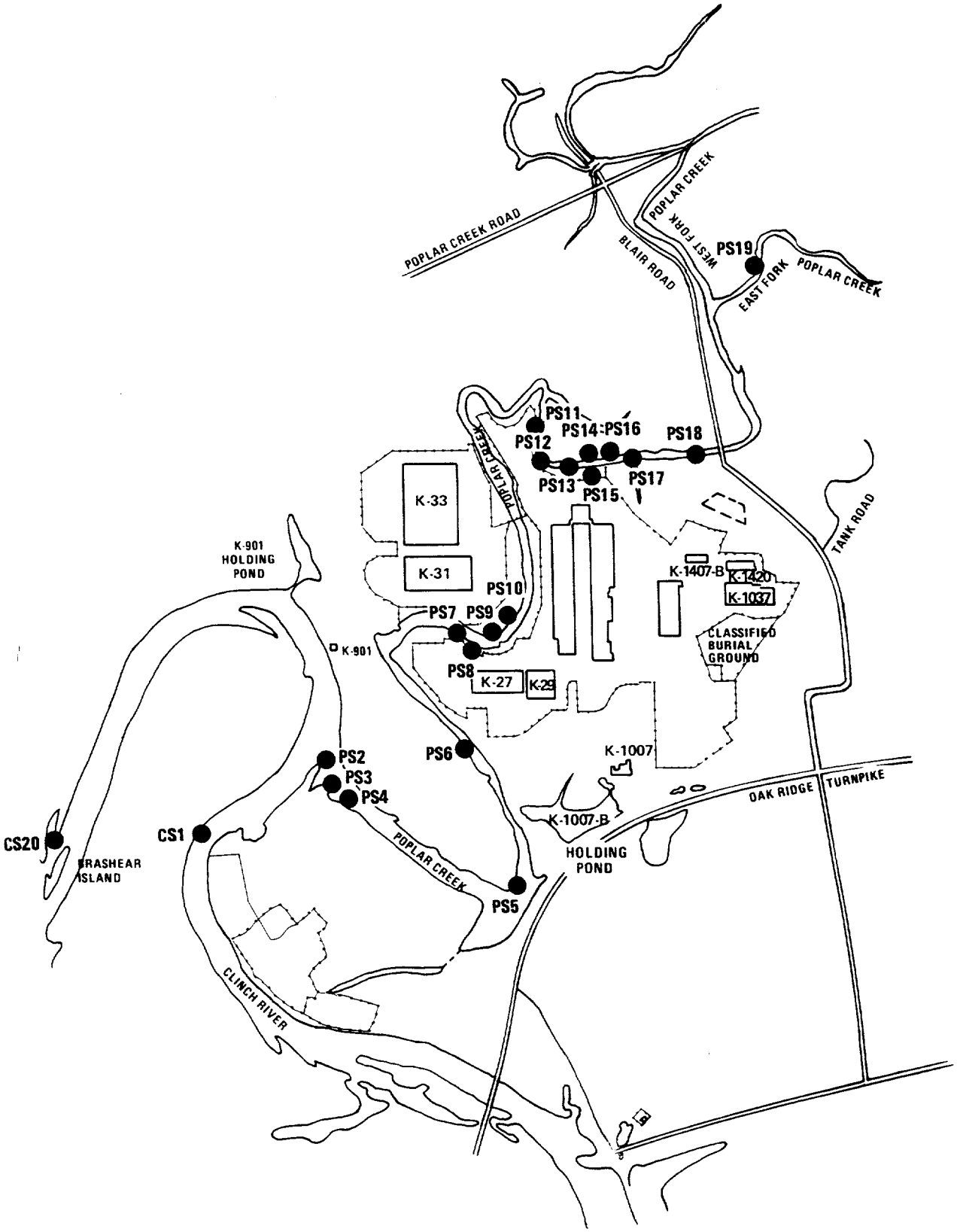

Figure 9

OAK RIDGE GASEOUS DIFFUSION PLANT
SURFACE WATER SEDIMENT SAMPLING LOCATIONS

The concentrations of metals in the stream sediment samples, Table 32, generally exceed background levels for metals in remote streams, except for cadmium and thorium which were below detectable limits. Since stream sediment sampling was initiated only a few years ago, there is an insufficient amount of data to draw meaningful conclusions, or observe discernable trends. If, however, the effluent sources are examined, it can be found that only very small quantities of any of these metals are currently being released, suggesting that present concentrations found in sediment samples are residual metals from earlier plant operations.

As a result of higher than background mercury concentrations in creek sediments and known use of large quantities of mercury at the Y-12 Plant until 1963, a fish study in Poplar Creek and the Clinch River was undertaken in 1976 and 1977 to determine the significance of these findings. Both migratory and nonmigratory fish, including edible and rough species, were studied.

During 1976 and 1977, 649 fish were analyzed. Sixty-two edible fish from this group contained mercury concentrations exceeding the proposed Food and Drug Administration (FDA) action level of 0.5 μg/g. Representative of average concentrations in fish taken from Poplar Creek near ORGDP are large-mouth bass 0.72 μg/g, bluegill 0.42 μg/g, and crappie 0.23 μg/g. Fish taken from the Clinch River near Poplar Creek showed average concentrations in largemouth bass of 0.38 μg/g, bluegill 0.15 μg/g, and crappie 0.14 μg/g.

While these mercury concentrations are higher than background measurements made from Melton Hill Reservoir fish (bass <0.02, bluegill <0.04, crappie 0.03), they do not constitute a toxicity hazard. The FDA proposed action level (proposed in December 1974) does not apply to individual fish, rather to averages, in order to control total mercury consumption. The action level is based on a consumption rate three times the national average plus an additional safety factor of ten as well. An overall safety factor of 30 results. Thus, while some of the fish taken in the vicinity of ORGDP exceeded the proposed action level, an extraordinarily high and protracted consumption rate of these fish would be needed in order to reach levels of concern.

Calculation of Potential Radiation Dose to the Public

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations.

The site boundary for the Oak Ridge complex was defined as the perimeter of the DOE controlled area.

Gaseous effluents are discharged from several locations within each of the three Oak Ridge facilities. For calculational purposes, the gaseous discharges are assumed to occur from only one vent from each site. Since the release points at ORGDP and the Y-12 Plant do not

physically approximate an elevated stack, their discharges are assumed to be from 10 meters above ground level; releases from ORNL are through elevated stacks. The meteorological data collected at the ORNL site were used for dispersion calculations. Concentrations of radionuclides contained in the air and deposited on the ground were estimated at distances up to 50 miles from the Oak Ridge facilities with the Gaussian plume model developed by Pasquill[11] and Gifford[12] incorporated in a computer program.[13] The concentration has been averaged over the crosswind direction to give the estimated ground level concentration downwind of the source of emission.[14] The deposition velocities used in the calcualtions were 10^{-6} cm/sec for krypton and xenon, 10^{-2} cm/sec for iodine, and 1 cm/sec for particulates.[15]

Potential pathways of exposure to man from radioactive effluents released by the Oak Ridge operations that are considered in the dose estimates are presented in Figure 10. The pathways shown in the figure are not exhaustive, but they include the principal pathways of exposure based on experience.

Exposures to radionuclides that originate in the effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals using models and data presented in publications of the International Commission on Radiological Protection,[16-21] other recognized literature on radiation protection,[22-24] personal communication,[25] and computer programs incorporating some of these models and data.[26,27] Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay; thus the estimates for internal dose are called "dose commitments;" they are obtained by integrating over the assumed remaining lifetime (50 years) of the exposed individual.

The radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal, but they may vary considerably for internal exposures because some radionuclides concentrate in certain organs of the body. For this reason, estimates or radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract were considered for various pathways of exposure. These estimates were based on parameters applicable to an average adult.[16, 21] The population dose estimate (in man-rem) is the sum of the total body doses to exposed individuals within a 50-mile radius of the Oak Ridge facilities.

Maximum Potential Exposure — The point of maximum potential exposure ("fence-post" dose) on the site boundary is located along the bank of the Clinch River adjacent to a cesium field experimental plot and is due primarily to "sky-shine" from the plot. A maximum potential total body exposure of 260 mrem/yr was calculated for this location assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 52 percent of the allowable standard.[1] This is an atypical exposure location and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

The total body dose to a "hypothetical maximum exposed individual" at the same location

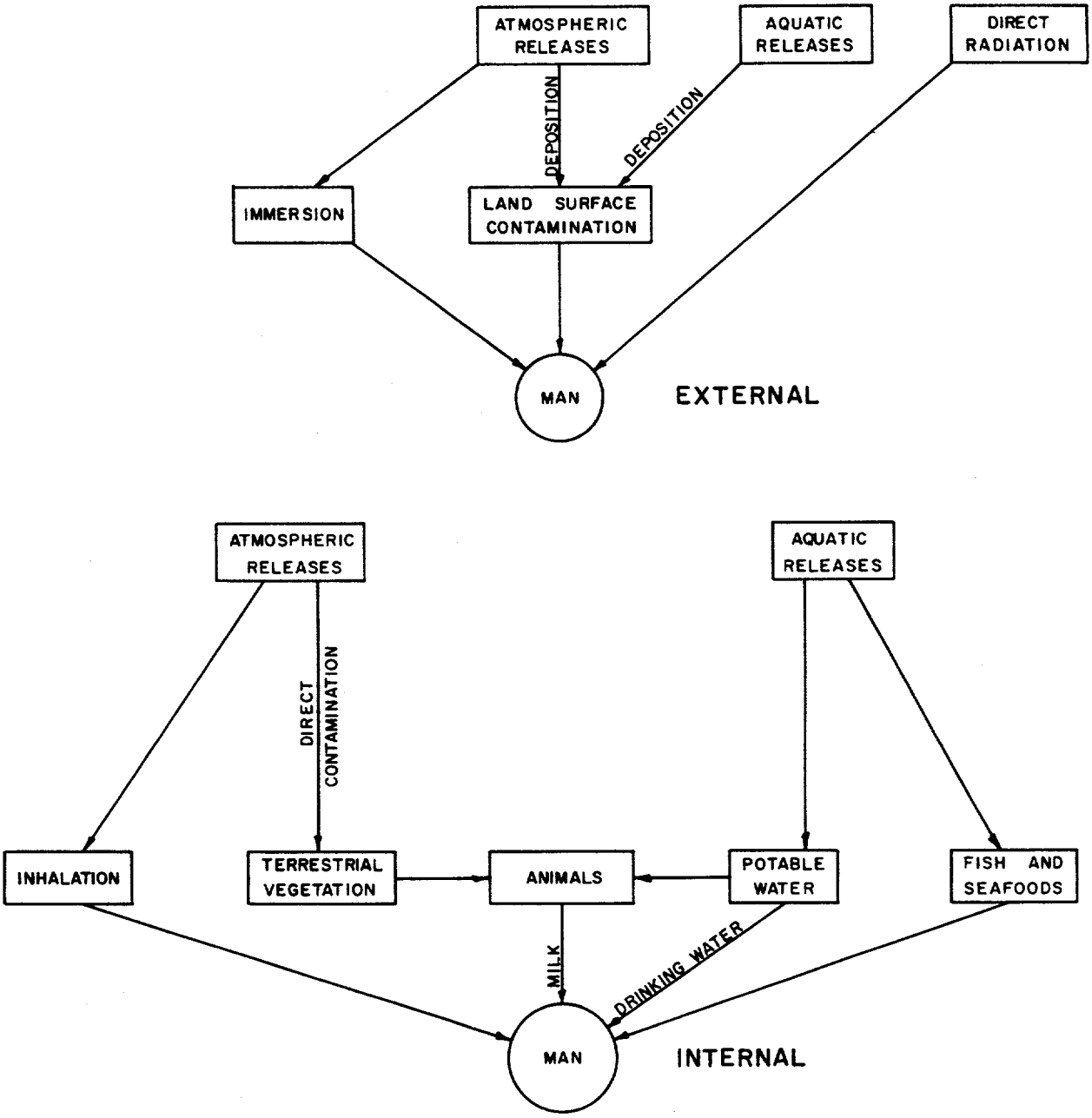

Figure 10
EXPOSURE PATHWAYS

was calculated using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 7.2 mrem/yr which is 1.4 percent of the allowable standard[1] and represents what is considered a probable upper limit of exposure.

A more probable exposure potential might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The dose commitment to an individual continuously occupying the residence nearest the site boundary would result from inhalation and is based on an inhalation rate for the average adult of 2×10^4 liters/day. The calculated dose commitments at this location were 4.6 ± 150% millirem to the lung (the critical organ) and 0.13 ± 150% millirem to the total body; uranium-234 is the important radionuclide contributing to this dose. These levels are 0.3 percent and 0.03 percent, respectively, of the allowable annual standard.

The most important contribution to dose from radioactivity within the food-chain is by the atmosphere-pasture-cow-milk food-chain pathway. Measurements of the two principal radionuclides entering into this pathway, ^{131}I and ^{90}Sr (see Table 25 and 26), indicate that the maximum dose to an individual in the immediate environs from ingestion of one liter of milk per day is 1.5 mrem to the thyroid at Station 5 and 5.5 mrem to the bone at Station 6. The average concentrations for the remote stations were assumed to be background and were subtracted from the perimeter station data in making the calculations.

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located approximately 16 miles downstream at Kingston, Tennessee. The intake to the water filtration plant is located on the Tennessee River approximately one-half mile upstream from the confluence of the Clinch and Tennessee Rivers. Normally, Tennessee River water is used for the Kingston water supply but under certain conditions of power generation, backflow can occur. Under backflow conditions, Clinch River water may move upstream in the Tennessee River and be used as the source of water for the Kingston filtration plant. It is estimated that these conditions would prevail a maximum of 20 percent of the time. Measurements of untreated river water samples at Kingston (see Table 11) indicate that the maximum dose commitment resulting from the ingestion of 20 percent of the daily adult requirement (about two liters per day) is 0.33 millirem to the bone; ^{90}Sr present in the waters upstream of the Oak Ridge facilities accounts for 55 percent (0.18 millirem) of this dose. The resulting 0.15 millirem is about 0.001 percent of the annual standard.

Estimates of the 50-year dose commitment to an adult were calculated for consumption of 37 pounds of fish per year from the Clinch River. The consumption of 37 pounds[8] is about 2.5 times the national average fish consumption[28] and is used because of the popularity of fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Table 27), the maximum organ dose commitment to an individual from the bluegill samples taken from the river near White Oak Creek outfall is estimated to be 110 millirem to the bone from ^{90}Sr. The maximum total body dose to an individual was calculated to be 3.7 millirem from the bass samples collected at the same location. These doses are 7.3 percent and 0.7 percent, respectively, of the allowable annual standard. Fish

samples taken from above White Oak Creek were analyzed to determine background conditions.

Summaries are given in Table 33 of the potential radiation doses to adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

Dose to the Population – The Oak Ridge population received the largest average individual total body dose as a population group. The average total body dose to an Oak Ridge resident was estimated to be 0.04 ± 150% millirem as compared to approximately 100 mrem/yr from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.3 ± 150% millirem. The maximum potential dose commitment to an Oak Ridge resident was calculated to be 4.6 ± 150% millirem to the lung. This calculated dose is 0.3 percent of the allowable annual standard.[1]

The cumulative total body dose to the population within a 50-mile radius of the Oak Ridge facilities resulting from 1977 plant effluents was calculated to be 4.7 ± 150% man-rem. This cumulative dose was calculated using the population distribution given in Table 1 for ORNL atmospheric effluents; similar population distributions were used for the Y-12 and ORGDP releases. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation. About 30 percent of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

Table 1

INCREMENTAL POPULATION TABLE IN THE VICINITY OF ORNL

DISTANCE, MILES DISTANCE, KM	0-1 0-1.6	1-2 1.6-3.2	2-3 3.2-4.8	3-4 4.8-6.4	4-5 6.4-8.0	5-10 8-16	10-20 16-32	20-30 32-48	30-40 48-64	40-50 64-80
Direction										
E	0	0	0	0	0	3,059	44,880	100,500	11,790	12,390
ENE	0	0	0	0	0	0	27,460	74,690	18,720	13,870
NE	0	0	0	0	0	9,713	12,480	7,167	4,392	7,476
NNE	0	0	0	0	1,461	13,780	4,362	11,190	12,670	6,119
N	0	0	0	0	1,490	5,578	2,177	1,441	2,223	4,508
NNW	0	0	0	0	0	1,495	0	1,152	4,559	4,676
NW	0	0	0	0	0	1,073	4,804	1,538	1,896	7,552
WNW	0	0	0	0	0	587	2,971	1,543	0	4,151
W	0	0	0	0	0	666	13,100	4,595	9,038	7,318
WSW	0	0	0	0	0	622	9,862	3,495	4,562	4,204
SW	0	0	0	0	0	733	1,840	1,909	3,962	8,578
SSW	0	0	0	0	0	721	2,055	7,897	21,580	10,530
S	0	0	0	0	0	943	8,742	7,309	6,560	1,222
SSE	0	0	0	0	1,374	7,277	1,290	4,091	469	0
SE	0	0	0	0	0	1,167	4,304	15,010	46	0
ESE	0	0	0	0	0	6,096	5,343	36,020	4,132	6,840
TOTAL	0	0	0	0	4,325	53,510	145,670	279,547	106,599	99,434
CUMULATIVE TOTAL	0	0	0	0	4,325	57,835	203,505	483,052	589,651	689,085

Table 2

CONTINUOUS AIR MONITORING DATA

Long-Lived Gross Beta Activity of Particulates in Air

1977

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-13} μCi/ml			% CG[c]
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]				
HP-31	Kerr Hollow Gate	52	1.4	0.02	0.46 ± 0.08	0.05
HP-32	Midway Gate	52	1.5	0.04	0.46 ± 0.08	0.05
HP-33	Gallaher Gate	51	1.4	0.01	0.28 ± 0.06	0.03
HP-34	White Oak Dam	52	1.4	0.05	0.38 ± 0.08	0.04
HP-35	Blair Gate	51	1.9	0.08	0.51 ± 0.10	0.05
HP-36	Turnpike Gate	52	1.9	0.11	0.54 ± 0.10	0.05
HP-37	Hickory Creek Bend	52	1.3	0.02	0.38 ± 0.08	0.04
HP-38	East of EGCR	52	1.5	0.07	0.43 ± 0.08	0.04
HP-39	Townsite	51	1.7	0.11	0.46 ± 0.10	0.05
Average					0.43 ± 0.03	0.04
		Remote Area[e]				
HP-51	Norris Dam	52	3.1	0.02	0.50 ± 0.14	0.05
HP-52	Loudoun Dam	51	2.4	0.05	0.50 ± 0.14	0.05
HP-53	Douglas Dam	49	1.4	0.08	0.44 ± 0.08	0.04
HP-54	Cherokee Dam	52	1.4	0.08	0.54 ± 0.10	0.05
HP-55	Watts Bar Dam	52	1.2	0.03	0.41 ± 0.08	0.04
HP-56	Great Falls Dam	50	2.6	0.07	0.51 ± 0.12	0.05
HP-57	Dale Hollow Dam	52	3.0	0.12	0.59 ± 0.14	0.06
HP-58	Knoxville	51	1.5	0.07	0.46 ± 0.08	0.05
Average					0.49 ± 0.04	0.05

[a] Maximum weekly average concentration.

[b] Minimum weekly average concentration — minimum detectable level is 3×10^{-6} μCi per sample.

[c] CG is 10^{-10} μCi/ml for unidentified radionuclides (DOE Manual, Appendix 0524, Annex A, Table II).

[d] See Figure 1.

[e] See Figure 2.

Table 3

CONTINUOUS AIR MONITORING DATA

Long-Lived Gross Alpha Activity of Particulates in Air

1977

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-15} μCi/ml			% CG[c]
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]				
HP-31	Kerr Hollow Gate	52	4.2	0.5	0.9 ± 0.2	0.02
HP-32	Midway Gate	52	6.5	0.7	1.2 ± 0.3	0.03
HP-33	Gallaher Gate	51	27.2	<0.1	<1.6 ± 1.0	<0.04
HP-34	White Oak Dam	52	2.5	0.5	1.0 ± 0.1	0.03
HP-35	Blair Gate	51	4.2	0.6	1.3 ± 0.2	0.03
HP-36	Turnpike Gate	52	3.3	0.5	1.0 ± 0.2	0.03
HP-37	Hickory Creek Bend	52	3.1	<0.1	<1.0 ± 0.2	<0.03
HP-38	East of EGCR	52	2.5	0.5	0.9 ± 0.1	0.02
HP-39	Townsite	51	4.5	0.6	1.1 ± 0.2	0.03
Average					<1.1 ± 0.1	<0.03
		Remote Area[e]				
HP-51	Norris Dam	52	4.2	<0.1	<0.8 ± 0.2	<0.02
HP-52	Loudoun Dam	51	4.5	<0.1	<0.9 ± 0.2	<0.02
HP-53	Douglas Dam	49	2.4	0.6	1.0 ± 0.1	0.03
HP-54	Cherokee Dam	52	2.6	0.5	0.7 ± 0.1	0.02
HP-55	Watts Bar Dam	52	2.4	0.5	0.9 ± 0.1	0.02
HP-56	Great Falls Dam	50	3.3	0.6	0.9 ± 0.2	0.02
HP-57	Dale Hollow Dam	52	4.2	<0.1	<0.8 ± 0.2	<0.02
HP-58	Knoxville	51	8.2	0.5	0.9 ± 0.3	0.02
Average					<0.9 ± 0.1	<0.02

[a] Maximum weekly average concentration.

[b] Minimum weekly average concentration – minimum detectable level is 2×10^{-6} μCi per sample.

[c] CG is 40×10^{-13} μCi/ml for a mixture of uranium isotopes. (DOE Manual, Appendix 0524, Annex A, Table II).

[d] See Figure 1.

[e] See Figure 2.

Table 4
CONTINUOUS AIR MONITORING DATA
Specific Radionuclides in Air
(Composite Samples)
1977
Units of 10^{-15} μCi/ml

	PERIMETER STATIONS					REMOTE STATIONS				
RADIONUCLIDE	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Yearly Average	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Yearly Average
^{7}Be	127	140	121	101	122	132	170	127	99	132
^{54}Mn	ND*	0.22	0.27	0.16	$\leq$ 0.22	$\sim$ 0.048	ND	ND	0.18	$\leq$ 0.18
^{57}Co	0.10	ND	ND	ND	$\leq$ 0.1	ND	ND	ND	ND	ND
^{60}Co	ND	$\sim$ 0.0054	0.11	ND	$\leq$ 0.11	ND	0.018	ND	ND	$\leq$ 0.018
^{90}Sr	0.46	1.1	2.2	1.4	1.3	0.50	1.6	1.9	2.6	1.7
^{95}Zr	8.3	35	19	6.5	17	12	42	20	7.8	21
^{95}Nb	15.0	70	35	23	36	23	84	38	25	43
^{103}Ru	9.3	19	16	4.8	12	11	22	18	5.5	14
^{106}Ru	2.3	14	18	10	11	2.7	20	14	11	12
^{125}Sb	0.16	1.4	1.8	0.87	1.1	0.42	1.7	2.1	1.0	1.3
^{137}Cs	0.42	2.1	2.2	1.8	1.6	0.42	2.2	2.2	1.7	1.6
^{141}Ce	7.7	11	17	4.5	10	13	12	20	4.7	12.4
^{144}Ce	3.8	30	30	18	21	5.4	36	30	18	22
^{228}Th	0.031	0.024	0.025	0.016	0.024	0.025	0.014	0.011	0.011	0.015
^{230}Th	0.033	0.021	0.017	0.013	0.021	0.023	0.012	0.0092	0.0092	0.013
^{232}Th	0.030	0.026	0.018	0.015	0.022	0.023	0.011	0.0084	0.0078	0.013
^{234}U	1.15	0.62	0.78	0.63	0.51	0.073	0.068	0.058	0.043	0.061
^{235}U	0.036	0.013	0.083	0.019	0.037	0.0026	0.0024	0.0032	0.0038	0.0030
^{238}U	0.44	0.33	0.43	0.73	0.48	0.043	0.035	0.027	0.041	0.037
^{238}Pu	0.00089	0.00051	0.0020	0.0022	0.0014	0.00013	0.00067	0.0016	0.0018	0.0011
^{239}Pu	0.0051	0.019	0.022	0.018	0.016	0.0048	0.025	0.020	0.017	0.019

*NOT DETECTABLE.

Table 5
CONCENTRATION OF ^{131}I IN AIR AS MEASURED
BY THE PERIMETER AIR MONITORING STATIONS[a]
1977

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-14} μCi/ml			% CG[d]
			MAXIMUM[b]	MINIMUM[c]	AVERAGE	
HP-31	Kerr Hollow Gate	52	1.91	0.17	0.67 ± 0.11	<0.01
HP-32	Midway Gate	52	8.12	0.22	0.86 ± 0.31	<0.01
HP-33	Gallaher Gate	51	2.09	0.19	0.75 ± 0.14	<0.01
HP-34	White Oak Dam	52	2.37	0.18	0.75 ± 0.14	<0.01
HP-35	Blair Gate	51	4.57	0.16	0.70 ± 0.20	<0.01
HP-36	Turnpike Gate	52	2.51	0.16	0.57 ± 0.12	<0.01
HP-37	Hickory Creek Bend	52	2.99	0.17	0.59 ± 0.14	<0.01
HP-38	East of EGCR	52	4.17	0.20	0.69 ± 0.17	<0.01
HP-39	Townsite	51	4.05	0.22	0.68 ± 0.19	<0.01
Average					0.69 ± 0.06	<0.01

[a] See Figure 1.

[b] Maximum weekly average concentration.

[c] Minimum weekly average concentration — minimum detectable amount of ^{131}I is 3×10^{-6} μCi per sample.

[d] CG is 1×10^{-10} μCi/ml (DOE Manual, Appendix 0524, Annex A, Table II).

Table 6

DISCHARGES OF RADIOACTIVITY TO THE ATMOSPHERE
1977

RADIONUCLIDE	CURIES DISCHARGED
Uranium[a]	0.06
^{131}I	1.4
^{3}H	< 2,500
^{133}Xe[b]	<42,000
^{85}Kr[b]	< 8,600
^{99}Tc	2×10^{-6}
Pu[c]	4×10^{-6}
Alpha[d]	2×10^{-8}

[a] Uranium of varying enrichments — curie quantities calculated using the appropriate specific activity for material released.

[b] Upper limit values based on direct radiation instrument measurements in the stack gas stream and an assumed mixture of noble gases.

[c] Mixture of all isotopes.

[d] Unidentified alpha.

Table 7
AIR MONITORING DATA – FLUORIDES
1977

LOCATION[a]	NUMBER OF SAMPLES		MAXIMUM CONCENTRATION FOR AVERAGING INTERVAL (ppb)			NUMBER OF TIMES STANDARD EXCEEDED[b]			ANNUAL AVERAGE (ppb)
	24 HOUR	7 DAY	24 HOUR	7 DAY	30 DAY	24 HOUR	7 DAY	30 DAY	
F-1	26	16	11.0	1.6	3.7	1	0	2	<1.0 ± 0.6
F-2	25	19	3.4	2.2	1.9	0	1	1	<0.9 ± 0.3
F-3	25	19	1.5	1.3	0.8	0	0	0	<0.6 ± 0.1
F-4	25	19	3.5	1.5	1.4	1	0	0	<0.8 ± 0.2
F-5	25	19	3.2	0.9	1.4	0	0	0	<0.6 ± 0.2
F-6[c]	22	15	1.7	0.7	1.2	0	0	0	<0.6 ± 0.2

[a] See Figure 1.

[b] Tennessee Air Pollution Control Regulations –
4.5 ppb for 12 hour averaging interval
3.5 ppb for 24 hour averaging interval
2.0 ppb for 7 day averaging interval
1.5 ppb for 30 day averaging interval
All values are maximum – not to be exceeded more than once per year.

[c] Station F-6 is approximately 5 miles from ORGDP upwind of the predominant prevailing wind direction, thus may be considered representative of general ambient background concentration.

NOTE: Data not amenable to comparison with 12 hour standard.

Table 8
AIR MONITORING DATA – SUSPENDED PARTICULATES
1977

LOCATION[a]	NUMBER OF SAMPLES	CONCENTRATION, $\mu g/m^3$			% STD.[b]
		MAXIMUM	MINIMUM	AVERAGE	
SP-1	32	166.6	1.2	43.2 ± 16.0	58
SP-2	36	153.9	6.8	44.6 ± 11.6	59
SP-3	36	165.5	17.9	51.4 ± 13.5	68
SP-4	32	156.7	20.1	48.3 ± 12.9	64

[a] See Figure 1.

[b] Tennessee Air Pollution Control Regulations – Primary standard based on annual geometric mean is 75.0 $\mu g/m^3$.

Table 9
SULFUR DIOXIDE MONITORING DATA
1977

MONTH	MAXIMUM 24 HR. AVERAGE (PPM)		MONTHLY AVERAGE (PPM)	
	STATION S-1	STATION S-2	STATION S-1	STATION S-2
January	0.04	0.05	0.017	0.015
February	0.07	0.05	0.023	0.010
March	0.03	0.07	0.014	0.011
April	0.04	0.01	0.014	0.006
May	0.02	0.08	0.007	0.016
June	0.04	0.05	0.010	0.010
July	0.02	0.02	0.010	0.012
August	0.01	0.02	0.007	0.010
September	0.01	0.02	0.008	0.010
October	0.02	0.05	0.008	0.024
November	0.01	0.05	0.008	0.033
December	0.03	No data	0.011	No data
Annual Arithmetic Mean			0.011	0.014

Tennessee Ambient Standards
Maximum 24 hr. Average – 0.14 ppm
Annual Arithmetic Mean – 0.03 ppm
Minimum Detectable Limit – 0.005 ppm

Table 10
EXTERNAL GAMMA RADIATION MEASUREMENTS
1977

STATION NUMBER	LOCATION	NUMBER OF MEASUREMENTS TAKEN	BACKGROUND μR/hr	BACKGROUND mR/yr
		Perimeter Stations[a]		
HP-31	Kerr Hollow Gate	12	8.5 ± 1.1	74 ± 10
HP-32	Midway Gate	12	10.8 ± 1.0	95 ± 9
HP-33	Gallaher Gate	12	7.9 ± 0.7	69 ± 6
HP-34	White Oak Dam	12	12.3 ± 0.8	108 ± 7
HP-36	Blair Gate	12	7.3 ± 0.7	64 ± 6
HP-36	Turnpike Gate	12	7.5 ± 0.8	66 ± 7
HP-37	Hickory Creek Bend	12	7.5 ± 0.7	66 ± 6
HP-38	East of EGCR	12	7.6 ± 0.7	67 ± 6
HP-39	Townsite	12	7.9 ± 0.7	69 ± 6
HP-40	Melton Hill	12	6.1 ± 0.6	53 ± 5
Average			8.3 ± 0.3	73 ± 2
		Remote Stations[b]		
HP-51	Norris Dam	2	6.7 ± 0.1	59 ± 1
HP-52	Loudoun Dam	2	7.8 ± 0.3	68 ± 3
HP-53	Douglas Dam	2	8.1 ± 1.5	71 ± 13
HP-54	Cherokee Dam	2	7.6 ± 1.6	67 ± 14
HP-55	Watts Bar Dam	2	6.8 ± 0.5	60 ± 4
HP-56	Great Falls Dam	2	7.5 ± 3.7	66 ± 32
HP-57	Dale Hollow Dam	2	8.5 ± 1.5	74 ± 13
HP-58	Knoxville	2	10.8 ± 0.5	95 ± 4
Average			8.0 ± 0.6	70 ± 5

[a] See Figure 1.

[b] See Figure 2.

Table 11
RADIONUCLIDES IN THE CLINCH RIVER
1977

LOCATION	NUMBER OF SAMPLES	RANGE	CONCENTRATION OF RADIONUCLIDES OF PRIMARY CONCERN UNITS OF 10^{-9} μCi/ml				% CG[c]
			^{90}Sr	^{137}Cs	^{106}Ru	^{3}H	
C-2 CRM 23.1[a]	4	Max.	0.23	<0.01	0.14	640	
		Min.	0.05	<0.01	0.09	390	
		Avg.	0.15 ± 0.08	<0.01	0.10 ± 0.02	490 ± 100	<0.07
CRM 20.8[b]	12	Max.	1.85	0.26	0.15	4400	
		Min.	0.26	0.01	0.01	280	
		Avg.	0.62 ± 0.24	0.05 ± 0.04	0.05 ± 0.02	1450 ± 660	0.28
C-3 CRM 14.5[a]	4	Max.	0.36	0.05	0.23	3050	
		Min	0.05	<0.01	0.09	1300	
		Avg.	0.18 ± 0.16	<0.03 ± 0.02	0.15 ± 0.06	1800 ± 850	<0.13
C-5 CRM 4.5[a]	4	Max.	0.41	0.5	0.32	2050	
		Min.	0.05	0.5	0.09	450	
		Avg.	0.27 ± 0.18	0.5	0.19 ± 0.10	1000 ± 730	0.13

[a] Measured values in the Clinch River.

[b] Values given for this location are calculated values based on the concentrations measured at White Oak Dam (Station W-1) and the dilution afforded by the Clinch River. They do not include radioactive materials (e.g., fallout) that may enter the river upstream of White Oak Creek outfall (CRM 20.8). The yearly average dilution factor was 537.

[c] Most restrictive concentration guide for each isotope used for calculating percent concentration guide. The method for calculating percent of concentration guide for a known mixture of radionuclides is given in DOE Manual, Appendix 0524, Annex A.(1)

Table 12
URANIUM CONCENTRATION IN SURFACE STREAMS
1977

STATION NUMBER[a]	LOCATION	NUMBER OF SAMPLES	UNITS OF 10^{-8} μCi/ml			% CG[b]
			MAXIMUM	MINIMUM	AVERAGE	
P-1	Poplar Creek	12	4.3	0.09	1.0 ± 2.0	<0.1
P-2	Poplar Creek	12	1.5	0.09	0.6 ± 0.3	<0.1
C-3	Clinch River	12	1.5	0.09	0.3 ± 0.2	<0.1
C-4	Clinch River	12	0.7	0.09	0.3 ± 0.1	<0.1
C-6	Clinch River	12	0.5	0.09	0.2 ± 0.08	<0.1
E-1	East Fork Poplar Creek	12	3.8	1.4	2.3 ± 0.5	<0.1
B-1	Bear Creek	12	7.4	1.1	2.9 ± 1.1	<0.1

[a] See Figure 3.

[b] CG is 3×10^{-5} μCi/ml for a mixture of uranium isotopes (DOE Manual, Appendix 0524, Annex A, Table II).

Table 13
DISCHARGES OF RADIOACTIVITY TO SURFACE STREAMS
1977

RADIONUCLIDE	CURIES DISCHARGED
^{137}Cs	0.2
^{60}Co	0.4
^{3}H	6,300
^{131}I	0.03
^{106}Ru	0.2
^{90}Sr	2.7
^{99}Tc	15
Uranium[a]	2.2
^{232}Th	0.01
Transuranics[b]	0.03

[a] Uranium of varying enrichments — curie quantities calculated using the appropriate specific activity for material released.

[b] Value based on gross transuranic alpha emitter analysis.

Table 14
LONG-LIVED GROSS BETA ACTIVITY IN RAINWATER
1977

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-8} μCi/ml[a]
		Perimeter Taken[b]	
HP-31	Kerr Hollow Gate	37	4.5 ± 1.2
HP-32	Midway Gate	40	3.5 ± 0.9
HP-33	Gallaher Gate	41	4.9 ± 1.0
HP-34	White Oak Dam	42	3.7 ± 0.9
HP-35	Blair Gate	41	3.4 ± 0.9
HP-36	Turnpike Gate	43	4.0 ± 1.2
HP-37	Hickory Creek Bend	41	3.0 ± 0.9
HP-38	East of EGCR	41	5.0 ± 1.3
HP-39	Townsite	40	3.5 ± 1.1
Average			3.9 ± 0.4
		Remote Area[c]	
HP-51	Norris Dam	46	5.8 ± 1.2
HP-52	Loudoun Dam	36	6.2 ± 1.3
HP-53	Douglas Dam	40	5.1 ± 1.1
HP-54	Cherokee Dam	44	5.8 ± 1.0
HP-55	Watts Bar Dam	39	4.8 ± 1.1
HP-56	Great Falls Dam	44	5.6 ± 1.3
HP-57	Dale Hollow Dam	37	5.1 ± 1.1
HP-58	Knoxville	40	4.1 ± 0.8
Average			5.3 ± 0.4

[a] Weekly averaged concentrations.

[b] See Figure 1.

[c] See Figure 2.

Table 15
CHEMICAL WATER QUALITY DATA – WHITE OAK DAM
(Location W-1, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MINIMUM	MAXIMUM	AVERAGE	STD.[a]	
Cr	12	0.007	0.001	0.003 ± 0.002	0.05	6
Zn	12	0.03	0.0002	0.005 ± 0.02	0.1	5
NO_3(N)	12	2.0	0.04	0.8 ± 0.6	10	8
Hg	12	0.002	0.00006	0.0003 ± 0.0005	0.005	6

[a] Tennessee Stream Guidelines.

Table 16
CHEMICAL WATER QUALITY DATA – MELTON HILL DAM
(Location C-2, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MINIMUM	MAXIMUM	AVERAGE	STD.[a]	
Cr	12	0.00009	0.00001	0.00003 ± 0.00005	0.05	0.06
Zn	12	0.0005	0.00005	0.0002 ± 0.00005	0.1	0.2
NO_3(N)	12	3.3	0.002	0.4 ± 1.0	10	4
Hg	12	0.00003	<0.00001	<0.00002 ± 0.00003	0.005	<0.4

[a] Tennessee Stream Guidelines.

Table 17
CHEMICAL WATER QUALITY DATA – ORGDP SANITARY WATER PUMPING STATION
(Location C-3, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MINIMUM	MAXIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cr	12	0.02	0.005	< 0.01 ± 0.01	0.05	<20
CN	12	0.003	< 0.0005	< 0.001 ± 0.0004	0.01	<10
NO_3(N)	12	0.9	0.3	0.6 ± 0.1	10	6
Pb	12	< 0.01	< 0.01	< 0.01	0.05	<20
$SO_4^{=}$	12	40	14	23 ± 4	250	9
T.D.S.	12	278	107	158 ± 28	500	32
Zn	12	0.1	0.02	0.05 ± 0.02	0.1	50
F^-	12	0.1	< 0.1	< 0.1	1.0	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.02	< 0.005	< 0.008 ± 0.001	0.1	< 8

[a] Tennessee Stream Guidelines.

Table 18
CHEMICAL WATER QUALITY DATA – ORGDP RECIRCULATING WATER PUMPING STATION
(Location C-4, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cr	12	0.02	< 0.005	< 0.01 ± 0.01	0.05	<20
CN	12	0.007	< 0.0005	< 0.002 ± 0.001	0.01	<20
NO_3(N)	12	3.3	0.2	0.9 ± 0.5	10	9
Pb	12	0.02	< 0.01	< 0.01 ± 0.002	0.05	<20
$SO_4^{=}$	12	50	15	26 ± 6	250	10
T.D.S.	12	246	114	176 ± 23	500	35
Zn	12	0.05	0.01	0.02 ± 0.008	0.1	20
F^-	12	< 0.1	< 0.1	< 0.1	1.0	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.03	< 0.005	< 0.009 ± 0.004	0.1	< 9

[a] Tennessee Stream Guidelines.

Table 19
CHEMICAL WATER QUALITY DATA – CLINCH RIVER DOWNSTREAM OF ORGDP
(Location C-6, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cr	12	0.008	< 0.005	< 0.005 ± 0.0007	0.05	<10
CN	12	0.01	< 0.0005	< 0.002 ± 0.001	0.01	<20
$NO_3(N)$	12	1.1	0.08	0.5 ± 0.2	10	5
Pb	12	0.02	< 0.01	< 0.01 ± 0.002	0.05	<20
$SO\bar{4}$	12	45	13	22 ± 5	250	9
T.D.S.	12	236	90	159 ± 28	500	32
Zn	12	0.07	0.005	0.02 ± 0.01	0.1	20
F^-	12	0.2	< 0.1	< 0.1 ± 0.01	1.0	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.02	< 0.005	< 0.007 ± 0.003	0.1	< 7

[a] Tennessee Stream Guidelines.

Table 20
CHEMICAL WATER QUALITY DATA – EAST FORK POPLAR CREEK
(Location E-1, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.002	< 0.002	< 0.002	0.01	< 20
Cl^-	12	15	9	11 ± 1	250	4
Cr	12	0.09	< 0.01	< 0.02 ± 0.01	0.05	< 40
F^-	12	1.4	0.8	1.1 ± 0.1	1.0	110
Hg	12	0.003	< 0.0005	< 0.002 ± 0.0008	0.005	< 40
$NO_3(N)$	12	4	2	3 ± 0.3	10.0	30
Pb	12	0.02	< 0.01	< 0.01 ± 0.002	0.05	< 20
$SO_4^=$	12	52	24	39 ± 5	250	16
T.D.S.	12	250	176	206 ± 14	500	41
Zn	12	0.04	< 0.02	< 0.03 ± 0.004	0.1	< 30

[a] Tennessee Stream Guidelines.

Table 21
CHEMICAL WATER QUALITY DATA – BEAR CREEK
(Location B-1, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.002	<0.002	< 0.002	0.01	<20
Cl^-	12	9	3	5 ± 1	250	2
F^-	12	1.8	<0.1	< 0.3 ± 0.3	1.0	<30
NO_3(N)	12	16	2	9 ± 3	10	90
$SO\bar{4}$	12	16	<8	<10 ± 2	250	< 4
Zn	12	< 0.02	<0.02	< 0.02	0.1	<20

[a] Tennessee Stream Guidelines.

Table 22
CHEMICAL WATER QUALITY DATA – POPLAR CREEK ABOVE BLAIR BRIDGE
(Location P-1, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cr	12	0.02	< 0.005	< 0.006 ± 0.002	0.05	<12
CN	12	0.002	< 0.0005	< 0.001 ± 0.0008	0.01	<10
NO_3(N)	12	1.7	0.3	1.2 ± 0.3	10	12
Pb	12	0.3	0.01	0.03 ± 0.05	0.05	60
$SO_4^{=}$	12	45	28	36 ± 4	250	14
T.D.S.	12	294	112	201 ± 37	500	40
Zn	12	0.07	0.009	0.03 ± 0.01	0.1	30
F^-	12	0.4	0.1	0.3 ± 0.1	1.0	30
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.02	< 0.005	< 0.01 ± 0.01	0.1	<10

[a] Tennessee Stream Guidelines.

Table 23
CHEMICAL WATER QUALITY DATA – POPLAR CREEK NEAR CLINCH RIVER
(Location P-2, Figure 3)
1977

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	<50
Cr	12	0.02	0.008	0.01 ± 0.004	0.05	20
CN	12	0.007	< 0.0005	< 0.002 ± 0.001	0.01	<20
NO_3(N)	12	1.5	0.07	0.8 ± 0.3	10	8
Pb	12	< 0.01	< 0.01	< 0.01	0.05	<20
$SO_4^{=}$	12	45	15	35 ± 5	250	14
T.D.S.	12	238	98	182 ± 30	500	36
Zn	12	0.07	0.02	0.03 ± 0.01	0.1	30
F^-	12	0.4	< 0.01	< 0.2 ± 0.06	1.0	<20
Hg	12	0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.02	< 0.005	< 0.01 ± 0.003	0.1	<10

[a] Tennessee Stream Guidelines.

Table 24
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) EXPERIENCE
1977

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
ORNL				
001				
(White Oak Creek)	Dissolved Oxygen (min.)	5	—	43
	Dissolved Solids	—	2000	100
	Oil and Grease	10	15	100
	Chromium (Total)	—	0.05	100
	pH (pH units)	—	6.0 – 9.0	82
002				
(Melton Branch)	Chromium (total)	—	0.05	100
	Dissolved Solids	—	2000	100
	Oil and Grease	10	15	100
	pH (pH units)	—	6.0 – 9.0	100
003				
(Main Sanitary Treatment Facility)	Ammonia (N)	—	5	17
	BOD	—	20	90
	Chlorine Residual	—	0.5 – 2.0	99
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	—	6.0 – 9.0	100
	Suspended Solids	—	30	100
	Settleable Solids (ml/l)	—	0.5	87
004				
(7900 Area Sanitary Treatment Facility)	BOD	—	30	
	Chlorine Residual	—	0.5 – 2.0	No Discharges From This Facility
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	
	pH (pH units)	—	6.0 – 9.0	
	Suspended Solids	—	30	
	Settleable Solids (ml/l)		0.5	
Y-12 PLANT				
001				
(Kerr Hollow Quarry)	Dissolved Solids	—	2000	100
	Lithium	—	5	100
	pH (pH units)	—	6.0 – 9.0	100
	Suspended Solids	—	50	100
	Zirconium	—	3	No Disposals
002				
(Rogers Quarry)	pH (pH units)	—	6.0 – 9.0	88
	Suspended Solids[a]	30	50	100
	Setteable Solids (ml/l)[a]	—	0.5	100

Table 24
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
003				
(New Hope Pond)	Ammonia (N)	--	1.6	100
	Chromium	0.05	0.08	92
	Dissolved oxygen (Min.)	5	--	100
	Dissolved Solids	--	2000	100
	Fluoride	1.5	2.0	100
	Lithium	--	5	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 – 9.0	100
	Phosphate (as MBAS)	5	8	100
	Suspended Solids[a]	--	20	100
	Settleable Solids (ml/l)[a]	--	0.5	100
	Total Nitrogen (N)	--	20	100
	Zinc	0.1	0.2	98
004				
(Bear Creek)	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 – 8.5	100
ORGDP				
001				
(K-1700 Discharge)	Aluminum	--	1.0	75
	Chromium (Total)	0.05	0.08	92
	Nitrate	--	20	85
	Suspended Solids	30	50	88
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 – 9.0	98
002				
(K-1410 Metal	Cyanide		None Detectable	100
Plating Facility)	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 – 9.0	84
004				
(K-1131 Steam	pH (pH units)	--	6.0 – 9.0	100
Condensate Discharge)	Flow (MGD)	0.005	0.008	100
005				
(K-1203 Sanitary	Ammonia (N)	5[b]	7[c]	100
Treatment Facility)	BOD	15[b]	20[c]	96
	Chlorine Residual	--	0.5 – 2.0	95
	Dissolved Oxygen (Min.)	5	--	99
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	--	6.0 – 9.0	100
	Suspended Solids	30[b]	45[c]	89
	Settleable Solids (ml/l)	--	0.5	67

Table 24
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
006				
(K-1007B Holding	COD	20	25	100
Pond)	Chromium	—	0.05	94
	Dissolved Oxygen (Min.)	5	—	99
	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	—	6.0 – 9.0	99
	Suspended Solids[a]	30	50	100
007				
(K-901A Holding	Chromium (total)	—	0.05	29
Pond)	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	—	6.0 – 10	99
	Suspended Solids	30	50	100
008				
(K-710 Sanitary	BOD	30[b]	45[c]	100
Treatment Facility)	Suspended Solids	30[b]	45[c]	100
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	—	6.0 – 9.0	100
	Chlorine Residual	—	0.5 – 2.0	68
	Settleable Solids (ml/l)	—	0.1	100
009	Suspended Solids[a]	30	50	100
(Sanitary Water	Aluminum	—	250	100
Plant)	Sulphate	—	1400	100
	pH (pH units)	—	6.0 – 9.0	99

(a) Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface run-off resulting from precipitation.

(b) Monthly Average.

(c) Weekly Average.

Table 25

CONCENTRATION OF ^{131}I IN RAW MILK
1977

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μCi/ml			COMPARISON WITH STANDARD[b]
		MAXIMUM	MINIMUM[a]	AVERAGE	
			Immediate Environs[c]		
1	50	7	<0.45	<0.8	Range I
2	50	19	<0.45	<1.1	Range I
3	50	14	<0.45	<1.3	Range I
4	47	16	<0.45	<1.4	Range I
5	47	75	<0.45	<3.3	Range I
6	45	35	<0.45	<3.0	Range I
7	50	46	<0.45	<2.8	Range I
8	48	23	<0.45	<1.6	Range I
Average				<1.9 ± 0.7	Range I
			Remote Environs[d]		
51	8	8	<0.45	<1.4	Range I
52	9	4	<0.45	<1.2	Range I
53	11	2	<0.45	<0.8	Range I
54	9	4	<0.45	<1.1	Range I
55	9	6	<0.45	<1.2	Range I
Average				<1.1 ± 0.8	Range I

[a] Minimum detectable concentration of ^{131}I is 0.45×10^{-9} μCi/ml.

[b] Applicable FRC standard, assuming 1 liter per day intake:

Range I	0 to 1×10^{-8} μCi/ml	— Adequate surveillance required to confirm calculated intakes.
Range II	1×10^{-8} μCi/ml to 1×10^{-7} μCi/ml	— Active surveillance required.
Range III	1×10^{-7} μCi/ml to 1×10^{-6} μCi/ml	— Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[c] See Figure 4.

[d] See Figure 5.

Table 26
CONCENTRATION OF ^{90}Sr IN RAW MILK
1977

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μCi/ml			COMPARISON WITH STANDARD[b]
		MAXIMUM	MINIMUM[a]	AVERAGE	
			Immediate Environs[c]		
1	51	8.2	1.6	3.0	Range I
2	51	5.0	0.9	2.4	Range I
3	50	4.6	1.6	2.9	Range I
4	48	7.7	1.4	3.2	Range I
5	47	8.0	1.8	3.4	Range I
6	46	7.1	2.3	4.3	Range I
7	51	10.7	1.4	4.2	Range I
8	49	6.8	0.9	3.4	Range I
Average				3.4 ± 0.1	Range I
			Remote Environs[d]		
51	8	3.9	1.6	2.8	Range I
52	9	2.1	0.7	1.4	Range I
53	11	4.8	1.4	2.9	Range I
54	9	3.2	1.1	1.9	Range I
55	9	4.8	2.5	3.6	Range I
Average				2.5 ± 0.9	Range I

[a] Minimum detectable concentration of ^{90}Sr in milk is 0.5×10^{-9} μCi/ml.

[b] Applicable FRC Standard, assuming 1 liter per day intake:

Range I	0 to 2×10^{-8} μCi/ml	— Adequate surveillance required to confirm calculated intakes.
Range II	2×10^{-8} μCi/ml to 2×10^{-7} μCi/ml	— Active surveillance required.
Range III	2×10^{-7} μCi/ml to 2×10^{-6} μCi/ml	— Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[c] See Figure 4.

[d] See Figure 5.

Table 27
RADIONUCLIDE CONTENT OF CLINCH RIVER FISH
1977
pCi/kg Wet Weight

LOCATION	SPECIES[a]	^{40}K	^{60}Co	^{90}Sr	^{134}Cs	^{137}Cs	^{239}Pu	EST. % MPI[b]
CRM 22								
Above White Oak Creek and	Crappie	1980	⩽ 47	121	180	2038	<0.024	1.1
Below Melton Hill Dam	Blue Gill	3760	⩽ 39	27	101	670	0.112	0.28
	Carp	2400	⩽ 19	133	⩽ 19	154	<0.012	0.95
	Bass	2325	⩽ 13	13	⩽ 20	360	⩽0.013	0.13
	Shad	5691	⩽ 16	44	⩽ 63	49	⩽0.063	0.33
CRM 20.8								
Mouth of White Oak Creek	Crappie	2141	⩽ 39	150	⩽ 52	1461	0.007	1.2
	Blue Gill	2062	⩽ 72	815	⩽ 76	1397	0.086	5.8
	Carp	2309	⩽ 20	69	⩽ 29	306	<0.016	0.52
	Bass	2144	⩽ 55	330	⩽105	5397	<0.093	0.29
	Shad	2002	⩽217	43	⩽127	3187	0.027	0.66
CRM 12								
Below Mouth of Poplar Creek	Bass	878	⩽ 10	44	⩽ 20	⩽ 10	<0.02	0.31
	Shad	1608	47	145	74	734	0.082	1.1

[a] Composite of 10 fish in each species for CRM 22 and CRM 12; 20 fish in each species for CRM 20.8.

[b] Maximum Permissible Intake – Intake of radionuclide from eating fish is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of radionuclides in question. Consumption of fish is assumed to be 37 lb/yr of the species in question. Only man-made radionuclides were used in the calculation.

Table 28
RADIONUCLIDE CONCENTRATIONS IN DEER MUSCLE SAMPLES
1977
pCi/kg Wet Weight

SAMPLE NUMBER	LOCATION	ON OAK RIDGE RESERVATION	^{40}K	^{137}Cs	^{134}Cs	^{60}Co	^{65}Zn
D-1	Chestnut Ridge Park	No	4.14	0.416	ND*	∿0.026	∿0.078
D-2	Norris Lake	No	3.80	0.136	ND	ND	ND
D-3	K-25 Area	Yes	4.12	0.052	ND	ND	ND
D-4	White Oak Creek	Yes	4.55	2.26×10^3	10.4	Trace	Trace
D-5	Burial Ground No. 5	Yes	4.18	6.73	ND	0.080	0.586
D-6	Junction of Highway 95 and Bear Creek Road	Yes	4.87	2.25	ND	ND	ND
D-7	One-half mile east of 7000 Area, X-10	Yes	4.48	0.292	ND	ND	ND
D-8	Highway 95, one mile east of 95/58	Yes	4.50	0.537	ND	ND	ND

*NOT DETECTABLE.

Table 29
VEGETATION SAMPLING DATA
1977

STATION NUMBER[a]	F^- CONCENTRATION[b] µg/g (ppm)		U (TOTAL) CONCENTRATION[b] µg/g (ppm)	
	GRASS	PINE NEEDLES	GRASS	PINE NEEDLES
1	15	–	0.20	–
2	14	13	0.08	0.89
3	10	11	0.04	0.26
4	12	17	0.38	0.07
5	16	19	0.07	0.21
6	11	13	0.07	0.08
7	10	11	0.06	0.11
8	24	27	0.29	0.47
9	17	18	1.22	1.00
10	16[c]	–	0.16[c]	0.45[c]
11	29	32	0.53	0.82
12	15	13	0.12	0.24
13	17	–	0.51	–
14	11	–	0.27	–
15	11	–	0.07	0.25[c]
16	18	11	0.04	0.18
17	15	12	0.12	0.19

[a] See Figure 1.

[b] Average concentration of two sample collections, January and July. Analytical results are on a dry weight basis.

[c] Only one sample analyzed.

NOTE: Applicable guides for flora have not been established. However, for comparison the *American Industrial Hygiene Association Journal* for January-February 1969 (pp. 98-101) states that dairy cattle is the species of livestock most sensitive to fluorides in grasses. For comparative purposes the following fluoride concentrations and their effect on dairy cattle are given.

30 ppm	–	no adverse effects
30 to 40 ppm	–	borderline chronic
40 to 60 ppm	–	moderate chronic
60 to 110 ppm	–	severe chronic
above 250 ppm	–	acute

Table 30

RADIOACTIVITY IN GRASS SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS

1977

(Units of pCi/g – Dry Weight)

SAMPLING LOCATION[a]	^{7}Be	^{90}Sr	^{95}Nb	^{95}Zr	^{103}Ru	^{137}Cs	^{140}La	^{141}Ce	^{144}Ce	^{234}U	^{235}U	^{238}U	^{239}Pu
							Perimeter						
HP-23	17.1	5.3	9.5	4.4	2.8	0.44	8.9	8.1	6.9	0.40	0.013	0.82	0.0081
HP-31	20.4	3.3	12.6	6.4	4.3	0.65	11.0	10.8	7.3	0.21	0.0068	0.15	0.0077
HP-32	19.8	2.7	11.3	5.2	3.4	0.75	10.1	9.3	7.1	0.62	0.011	0.35	0.014
HP-33	11.7	3.1	11.5	5.8	2.5	0.40	6.7	7.8	5.3	0.14	0.0032	0.081	0.0072
HP-34	141	1.8	32.1	11.1	5.0	1.3	ND*	17.2	22.2	0.09	0.0027	0.030	0.0081
HP-35	21.6	3.1	14.9	6.7	3.7	1.3	12.7	11.9	9.7	0.50	0.013	0.26	0.021
HP-36	14.5	2.8	9.5	4.8	2.6	0.51	6.7	7.9	5.6	0.29	0.014	0.18	0.012
HP-37	89.2	2.7	24.1	7.8	3.9	0.75	ND	12.3	16.6	0.030	0.0018	0.028	0.0054
HP-38	107	1.6	21.4	7.6	3.5	1.1	ND	11.0	19.9	0.044	0.0023	0.026	0.0050
HP-39	19.5	3.4	13.9	7.0	4.2	0.35	ND	10.2	7.7	0.22	0.0090	0.17	0.0090
Average	46.2	3.0	16.1	6.7	3.6	0.76	< 9.4	10.7	10.8	0.25	0.0077	0.21	0.0098
							Remote						
HP-51	17.2	2.9	9.9	3.3	2.8	0.30	ND	9.9	6.3	0.037	0.0036	0.021	0.0036
HP-52	17.4	3.5	13.1	6.4	4.3	ND	11.8	10.5	7.2	0.086	0.0045	0.054	0.0081
HP-53	11.1	1.8	6.8	4.1	2.2	0.24	ND	6.2	5.6	0.32	0.013	0.34	0.0032
HP-54	10.5	2.3	4.3	3.0	1.6	ND	ND	4.1	4.3	0.15	0.0054	0.13	0.0023
HP-55	8.0	2.3	6.3	2.0	2.0	0.19	ND	6.3	3.7	0.086	0.0059	0.099	0.0054
HP-56	49.8	4.4	40.1	17.0	9.7	0.97	39.7	25.9	21.9	0.095	0.0023	0.063	0.0077
HP-57	8.0	1.3	3.2	1.6	0.8	0.29	ND	2.4	4.1	0.077	0.0041	0.059	0.0054
HP-58	8.5	0.7	2.3	1.7	0.6	0.58	ND	7.1	3.4	0.30	0.013	0.28	0.017
Average	16.3	2.4	10.8	4.9	3.0	<0.43	<25.8	9.1	7.1	0.14	0.0055	0.13	0.0066

[a] See Figures 1 and 2.

* Not detectable.

Table 31
SOIL SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS
(Units of pCi/g – Dry)[a]
1977

SAMPLING LOCATION[b]	^{40}K	^{90}Sr	^{137}Cs	^{226}Ra	^{234}U	^{235}U	^{238}U	^{238}Pu	^{239}Pu
					Perimeter				
HP-31	12.0	0.59	1.5	1.0	0.46	0.030	0.30	0.0020	0.018
HP-32	34.0	0.29	1.8	1.2	2.4	0.090	0.92	0.0014	0.025
HP-33	13.2	0.95	3.0	1.8	0.46	0.025	0.30	0.0050	0.044
HP-34	18.1	0.59	1.6	1.1	0.33	0.021	0.26	0.0090	0.023
HP-35	6.4	0.72	1.8	1.7	0.52	0.063	0.41	0.0014	0.027
HP-36	10.3	0.54	1.7	1.3	0.39	0.032	0.31	0.00090	0.028
HP-37	11.9	0.23	1.3	1.1	0.28	0.017	0.21	0.0032	0.014
HP-38	13.9	1.62	1.5	1.3	0.44	0.037	0.21	<0.00045	0.015
HP-39	18.1	0.72	1.8	1.2	0.98	0.072	0.95	0.0041	0.013
Average	15.1	0.69	1.8	1.3	0.70	0.043	0.43	<0.003	0.023
					Remote				
HP-51	9.6	0.38	2.1	1.5	0.25	0.015	0.19	0.0014	0.018
HP-52	17.4	0.59	1.3	1.5	0.55	0.030	0.47	0.0041	0.018
HP-53	NA	0.42	1.5	1.7	0.63	0.025	0.54	0.0018	0.018
HP-54	24.6	0.43	1.3	1.0	0.49	0.022	0.33	0.0045	0.0095
HP-55	7.4	0.63	1.4	1.6	0.44	0.050	0.39	0.0027	0.018
HP-56	5.8	0.37	1.7	1.2	0.25	0.015	0.23	0.0023	0.016
HP-57	20.0	0.23	1.3	1.2	0.41	0.018	0.36	0.0036	0.017
HP-58	19.6	0.31	1.4	1.4	0.36	0.016	0.31	0.00090	0.019
Average	14.9	0.42	1.5	1.4	0.42	0.024	0.35	0.0026	0.017

[a] Applicable guides for soil contamination have not been established.

[b] See Figures 1 and 2.

* Not analyzed.

Table 32
STREAM SEDIMENT SAMPLES
July/November 1977
Average Concentration (μg/g dry weight basis)

STATION	U	Hg	Pb	Ni	Cu	Zn	Cr	Mn	Cd	Al	Th
CS-1	2.1	0.3	56	33	27	74	44	1260	<5	36000	<20
PS-2	10.4	26.6	56	198	77	187	67	241	<5	42000	<20
PS-3	10.8	11.9	62	50	28	89	61	275	<5	43500	<20
PS-4	15.9	12.2	51	55	37	94	114	359	<5	35500	<20
PS-5	4.9	1.4	51	30	13	64	37	285	<5	33000	<20
PS-6	38.5	39.0	53	95	53	111	213	257	<5	32500	<20
PS-7	4.5	1.8	51	42	20	113	51	571	<5	36500	<20
PS-8	5.3	1.6	35	57	26	103	52	243	<5	42000	<20
PS-9	22.6	11.0	48	102	53	113	93	307	<5	31500	<20
PS-10	4.9	2.7	48	55	25	79	68	443	<5	49500	<20
PS-11	9.5	4.6	57	52	21	71	48	183	<5	28500	<20
PS-12	4.5	2.9	57	30	21	50	25	85	<5	29500	<20
PS-13	5.9	3.3	34	156	23	55	55	129	<5	37500	<20
PS-14	20.9	153.6	30	120	48	39	80	229	<5	38000	<20
PS-15	8.1	4.0	37	189	29	63	72	75	<5	45500	<20
PS-16	42.0	11.3	53	452	171	125	404	402	<5	52500	<20
PS-17	90.8	9.6	48	469	116	115	126	321	<5	49500	<20
PS-18	12.1	20.4	36	189	41	92	77	687	<5	49500	<20
PS-19	15.3	41.9	39	148	56	67	124	222	<5	45500	<20
CS-20	1.4	0.4	38	55	16	45	87	406	<5	45000	<20

NOTE: Stations PS-18 and PS-19 are above ORGDP and Station PS-2 is at the mouth of Poplar Creek.
Stations C-1 and C-20 are in the Clinch River upstream and downstream, respectively, of Poplar Creek outfall.

Table 33

SUMMARY OF THE ESTIMATED RADIATION DOSE
TO AN ADULT INDIVIDUAL DURING 1977 AT LOCATIONS OF MAXIMUM EXPOSURE

PATHWAY	LOCATION	DOSE (MILLIREM) TOTAL BODY	DOSE (MILLIREM) CRITICAL ORGAN
Gaseous Effluents			
Inhalation plus direct radiation from air and ground	Nearest resident to site boundary	0.13 ± 150%	4.6 ± 150% (lung)
Terrestrial food chains	Milk sampling stations (^{90}Sr)	0.11	5.5 (bone)
Liquid Effluents			
Aquatic food chains	Clinch-Tennessee River system	3.7 (^{137}Cs)	110 (bone ^{90}Sr)
Drinking water[a]	Kingston, Tennessee (^{90}Sr)	0.003	0.15 (bone)
Direct radiation along water, shores, and mud flats.[b]	Downstream from White Oak Creek near experimental Cs field plots	7.2	7.2 (Total body)

[a] Based on the analysis of raw (unprocessed) water; see text.

[b] Assuming a residence time of 240 hr/yr.

NOTE: Average background total body dose in the U.S.,[29] 106 mrem/yr.

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APPENDIX A
QUALITY ASSURANCE

Radiological

The Environmental Surveillance and Evaluation Section at Oak Ridge National Laboratory has initiated a quality assurance program to ensure that a high degree of accuracy and reliability is maintained in its surveillance activities. The program in effect at ORNL consists of quality control of techniques and procedures, and includes the establishment of a detailed written description of all activities pertaining to the Environmental Surveillance and Evaluation Section. This includes:

1. Operating procedures for each activity.
2. Inspection lists of operating and maintenance activities.
3. Check-off frequency lists for all quality assurance steps, such as schedules for equipment inspection and test control.
4. Documentation of compliance of quality assurance procedures.
5. Participation in intralaboratory and interlaboratory sample-exchange programs.
6. Evaluation of the adequacy of sample preparation work and data analysis.
7. Identification of the role, responsibilities, and authority of each staff member as related to quality assurance.

A schematic diagram showing a flow chart of this quality assurance program is given in Figure A1. A more detailed discussion of the ORNL QA program is given in Ref. (A1) & (A2).

Chemical

A Nuclear Division Committee on Environmental Analysis established an interlaboratory quality control program in 1977. The purpose of this program is to provide quality control data for environmental analysis within the Nuclear Division. A unified Environmental and Effluent Analysis Manual was issued in March of 1977 which contains 38 analytical procedures; EPA-certified analytical methods were used wherever possible.

All Nuclear Division analytical laboratories maintain internal measurement control programs that are part of planned and systematic actions taken to prevent incorrect results. Standard samples containing all parameters measured are purchased and submitted to the laboratories for analysis. Standard samples of known values are processed along with routine samples and the results are recorded and examined to determine if they fall within prescribed limits. Analytical results are transmitted to the Y-12 Plant Quality Control Department for statistical review and a semi-annual report is provided to the analytical laboratories.

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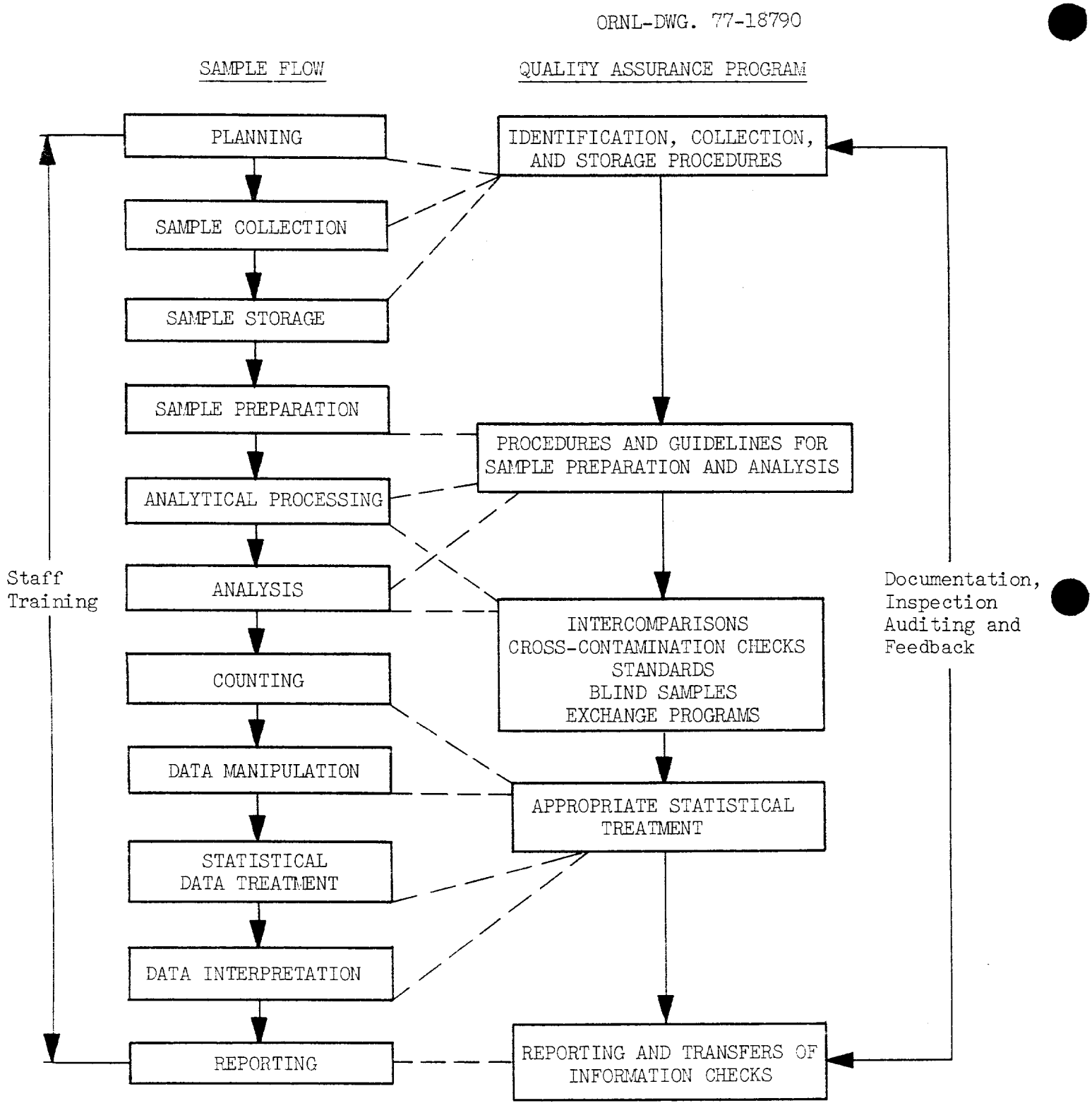

Fig. A1. FLOW CHART OF QA PROGRAM

EXTERNAL DISTRIBUTION

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